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Journal

—OF THE—

American Ceramic Society

A Monthly Journal devoted to the Arts and Sciences Related to the Silicate Industries.

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JOURNAL
OF THE
AMERICAN CERAMIC SOCIETY

A monthly journal devoted to the arts and sciences related to the silicate industries.

Vol. 2 **December, 1919** **No. 12**

EDITORIALS.

CHANGE OF EDITORSHIP.

The Committee on Publications regrets to announce the resignation of Editor George H. Brown which has been necessitated by the increasing pressure of his duties in connection with the Department of Ceramics at Rutgers College and the supervision of extension courses in the pottery center of Trenton. Mr. Brown's ability as Editor has been well demonstrated by the manner in which he has handled the publication of the Journal since its beginning in July, 1918, at a time when conditions required considerable initiative, resourcefulness and professional ability to launch a new technical publication.

On behalf of the American Ceramic Society the Committee on Publications desires to express appreciation of Mr. Brown's services in connection with the publication of Volumes 1 and 2 of this Journal, to wish him increasing success in the field of ceramic education in which his efforts are now to be concentrated and to hope that he will be a frequent contributor to the technical matter of the Journal, in the establishment of which his editorial services have been of the highest value.

In seeking a successor to Mr. Brown, the Board of Trustees has been fortunate in securing the services of Mr. Homer F. Staley of the Bureau of Standards, Washington, D. C. Mr. Staley is a graduate of Ohio State University, formerly director of the Department of Ceramics at Iowa State College, has had much experience in industrial lines, was editor of Volumes XIV and XV of the *Transactions of the American Ceramic Society* and is a past President of this Society. Mr. Staley is at present

Chief of the Sections of Enameled Metals and Refractories in the Bureau of Standards.

Mr. Staley is well equipped professionally and practically for his new duties as editor and the Committee on Publications looks forward to progressive success in the policies governing the publication of the Journal under his editorial direction which will commence with Volume 3, Number 1 or the January number of 1920.

L. E. BARRINGER,
Chairman, Committee on Publications.

DIVERSIFICATION OF TECHNICAL CONTRIBUTIONS TO THE JOURNAL.

In Volume 1, Number 12 of this Journal there was given a tabulation showing the diversification of the professional or technical papers published in the twelve numbers of Volume 1.

With the completion of Volume 2 by this number, a comparison can now be made between the diversification of papers in Volumes 1 and 2 and the following tabulation is submitted by the Committee on Publications for the information of our readers and contributors:

SUBJECT CLASSIFICATION.	Number of Papers. Vol. 1.	Vol. 2.
Clays, occurrence and uses	5	7
Refractories (fire-brick, saggers, retorts, glass-pots, etc.)	7	8
Porcelain and white ware	7	13
Glass	9	13
Lime and cement	5	4
Graphite crucibles	0	6
Enamels for metals	7	4
Enamels and glazes for clay wares	0	1
Terra cotta	4	0
Drying and driers	3	0
Firing and kilns	5	0
Miscellaneous (methods of testing and analysis, apparatus, construction, etc.)	..	..

From a study of the above table it is evident that to preserve a distribution of subjects consistent with the importance of the various phases of the ceramic industry, there should be more

contributions covering the fields of brick, tile and terra cotta and also regarding the technicalities of the important operations of drying and firing. This is a matter entirely in the hands of our members and readers and those desiring more matter in a given line should themselves either contribute such matter or solicit contributions from those they know are qualified to write upon such specific subjects.

The seeming preponderance of papers upon glass in Volume 2 was no doubt occasioned by the unusual activity during the war in investigating problems in the manufacture of optical glass. Upon the other hand—those interested in glass have been active from the outset in contributing professional papers to the Journal and it is to be hoped that they will retain their enthusiasm and their place.

The papers upon porcelain and white ware have been most largely upon porcelain and greater activity upon the part of those interested in white ware is highly desirable.

The appearance of a number of papers upon graphite crucibles in Volume 2 was the result of war-time activities in connection with the manufacture of refractories for metal melting. The technicalities of this field have been well-handled and a continuance of contributions of this class will be welcomed by our readers.

The field of ceramics is broad, its problems are interesting and everchanging, the men bearing the responsibilities of its progress are capable and professional pride and enthusiasm is well-developed. Under these conditions it is anticipated that the contributions to Volume 3 will be even more diversified and far-reaching than heretofore.

ORIGINAL PAPERS AND DISCUSSIONS.

THE MANUFACTURE OF ENAMEL LINED APPARATUS.

By Emerson P. Poste.

The field of vitreous enameling includes several rather distinct lines of manufacture. The broadest classification would no doubt have to do with the material to which enamel is applied and would divide the industry into steel enameling and cast iron enameling.

Under the general head of steel enameling the most familiar line is the manufacture of cooking ware[1] and similar commodities. Another branch of the industry which has assumed large proportions is the manufacture of signs, reflectors, table tops and other miscellaneous shapes. A third type of product, differing quite essentially from the other two in construction and use, is apparatus made of enameled steel designed to meet the needs of the dairy, canning, pharmaceutical and chemical industries.

The most prominent line of cast iron enameling is the manufacture of sanitary ware.[2,3] There are also a large number of miscellaneous lines involving the enameling of cast iron, among which may be named the manufacture of stove parts, barber and dentist chairs and various ornamental pieces. In addition to the above lines of cast iron manufacture there has been on the market for sometime a line of cast iron enameled apparatus which has found its particular application in the pharmaceutical and chemical

[1] Landrum, "Enamels for Sheet Steel," *J. Ind. Eng. Chem.*, **4**, 561 (1912).

[2] Staley, "The Manufacture of Enameled Iron Sanitary Ware," *Trans. Am. Ceram. Soc.*, **8**, 172 (1906).

[3] Staley, "Preparation and Application of Enamels for Cast Iron," *J. Am. Ceram. Soc.*, **1**, 534 (1918).

industries.[1] Equipment of this type was largely imported prior to the war but is now being put on the market by various American manufacturers.

It is our present purpose to deal with the manufacture of steel and cast-iron apparatus including some details relative to the other types of enamels, largely by way of contrast.

There are various ways in which the manufacture of enameled apparatus may be considered. It will be our choice to outline first the manufacture of the steel piece to which the enamel is

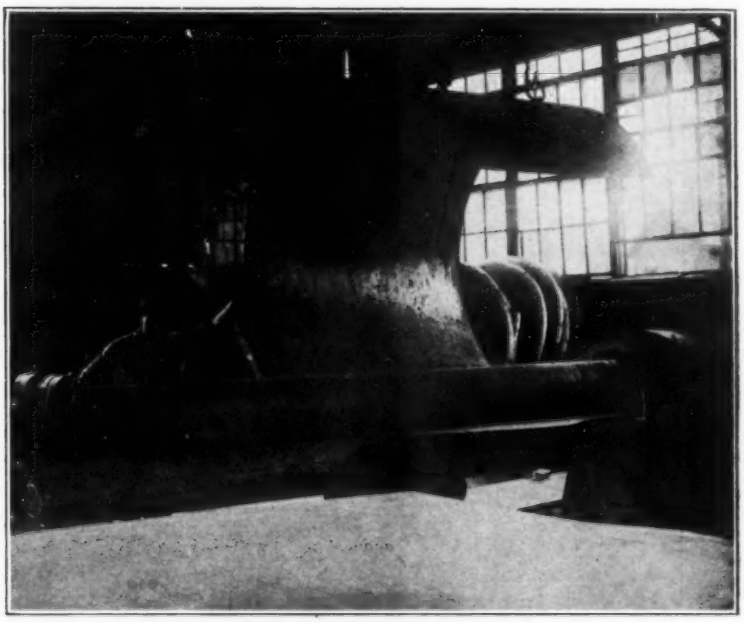

FIG. 1.—Plate in bending rolls.

to be applied, followed by a discussion of the manufacture of the cast iron piece. The question of enamel composition and preparation will be taken up, followed by the application and firing of the enamel on the steel or cast iron.

After considering some of the typical forms and uses of the

[1] "Acid Resisting Enamel Ware," *J. Am. Ceram. Soc.*, 1, 74 (1918).

finished apparatus a few points will be presented relative to rather technical features in connection with the manufacture and properties of enamels.

The Steel Shape.

The raw material which is to be formed into the final steel apparatus consists essentially of basic open-hearth plate, usually

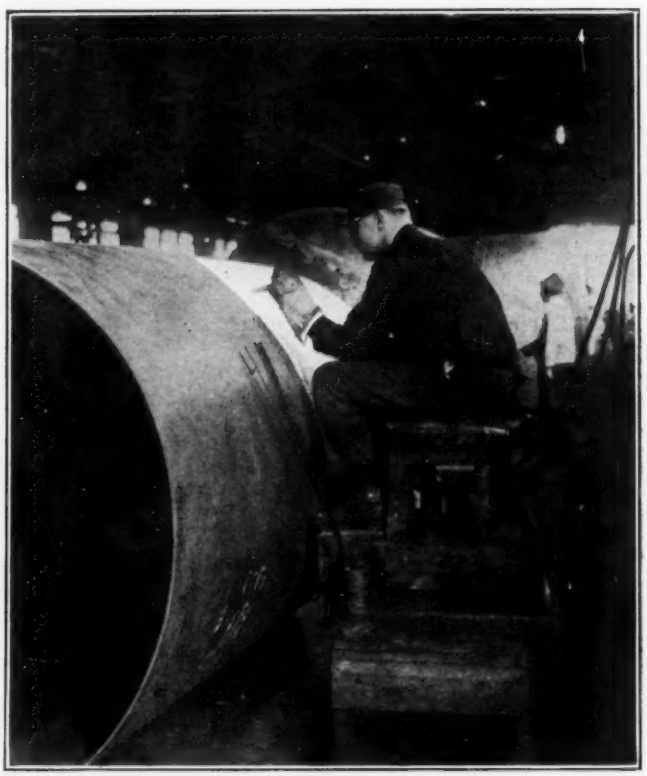

FIG. 2.—Oxyacetylene welding.

a quarter of an inch in thickness, sometimes thinner, sometimes thicker, while in other lines of steel enameling the material may be thin sheets of steel varying from 24 to 16 gauge..

The apparatus consists generally of circular units, closed or

open top, jacketed or unjacketed, with various openings and fittings. The design of the piece of equipment to be made having

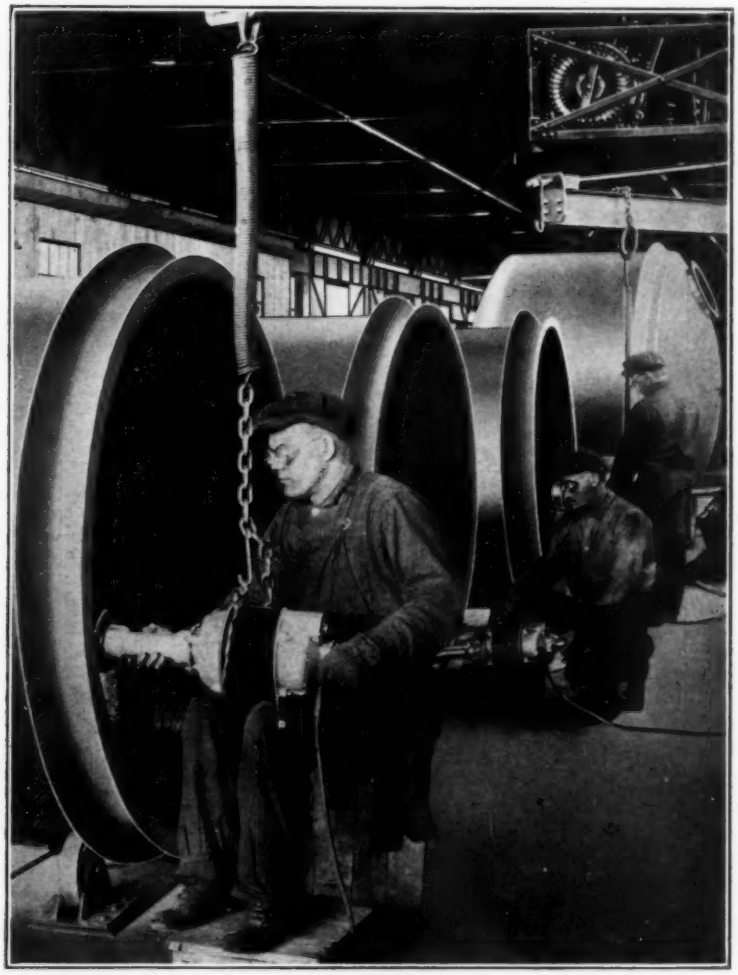

FIG. 3.—Grinding off weld.

been specified in the blue-print, sheets of the proper size are laid out in accordance with the drawing. The heads are then dished

to the specified depth and diameter and the plate, after trimming to the desired size, is put through the bending rolls and formed to the desired diameter.

The resulting cylinder is clamped in position and the longitudinal seam made by means of an oxyacetylene weld. Next,

FIG. 4.—Sandblasting a rectangular tank.

the bottom of the tank is attached to the shell in like manner and if it is to be a closed tank the top is welded on. The necessary openings in the form of inlets, outlets, manholes, etc., are then completed and the tank is ready to be prepared for enameling.

It is essential that the surface to be enameled be uniform

and clean and the first step to this end involves the grinding down of the weld by means of portable electric grinders.

The next step is the sandblasting of the entire surface of the unit so that wherever the enamel is to be applied there may be a surface free from impurities.

The sandblasting operation consists essentially of forcing a stream of sharp quartz sand against the surface to be cleaned. This is accomplished by passing air under pressure through a proper mixer at the bottom of a hopper in which the sand is stored. The air carries the sand through to the nozzle at a high rate of speed and causes it to be very forcibly thrown against the surface being treated.

In the case of cooking ware, or other thin steel products, the blanks are shaped either by pressing, spinning, or drawing, proper dies for such operations having previously been made. In preparation for enameling, the ware is thoroughly pickled and in some cases annealed in an annealing furnace. This operation accomplishes the removal of a considerable amount of scale which greatly facilitates the pickling which is to follow.

The Cast Iron Shape.

The blue-print, showing all the details necessary to the design of the piece of cast iron equipment to be enameled, goes to the pattern shop at which point the necessary patterns are produced, these in turn going to the foundry where the pieces are cast. The quality of the casting must be very good in order that a proper surface may be presented for receiving the enamel.

After leaving the foundry a certain amount of machine work is necessary to bring portions of the casting to proper dimensions, following which the piece goes to the sandblast and receives a treatment practically the same as that received by the steel apparatus.

The Enamel.

The preparation of the enamel which is to be applied to the ware, whether steel or cast iron, involves essentially three steps; mixing, smelting, and grinding.[1]

As to the formulas from which various enamels are prepared,

[1] *Loc. cit.*, *J. Am. Ceram. Soc.*, 1, 534 (1918).

it may be of interest to note certain typical compositions covering a rather large range of enameling technology.[1,2,3]

We herewith give the following formulas (Tables 1 and 2): No. 1 a steel ground coat; No. 2 a steel cover coat, white; No. 3 a cast iron ground coat; No. 4 a cast iron cover coat, white, all expressed in terms of the raw materials,[4] used for mixing.[5,6,7,8,9,10,11,12,13]

In the following tables the term "ground coat,"[5,6,7,8,9] in either case refers to the particular type of enamel which is applied to the freshly prepared metal while the term "cover coat,"[2,5] refers to the enamel which is applied above the ground coat and gives the finished appearance to the ware.

The mixing of the raw batch in accordance with a given formula may be accomplished by one of several means including shoveling, similar to the method used for mixing small amounts of concrete, or some type of mechanical mixing in which a whole batch is given

[1] Landrum, "A Comparison of Ten White Enamels for Sheet Steel," *Trans. Am. Ceram. Soc.*, **14**, 489 (1912).

[2] Riddle, "Types of Enamel Used for Enameling Cast Iron Sanitary Ware," *Ibid.*, **9**, 646 (1907).

[3] Staley, "Enamels for Cast Iron," *J. Am. Ceram. Soc.*, **1**, 703 (1918).

[4] Landrum, "The Function of the Various Raw Materials in a Sheet Steel Enamel," *Eighth International Congress of Applied Chemistry*, **25**, 317.

[5] Shaw, "The Allowable Limit of Variation in the Ingredients of Enamels for Sheet Steel," *Trans. Am. Ceram. Soc.*, **11**, 103 (1909).

[6] Landrum, "The Necessity of Cobalt Oxide in Ground-Coat Enamels for Sheet Steel," *Ibid.*, **14**, 756 (1912).

[7] Danielson, "The Effect of Variation in the Composition of Ground Coats for Sheet Iron Enamels," *Ibid.*, **18**, 896 (1916).

[8] Coe, "A Comparison of Commercial Ground Coats for Cast Iron Enamels," *Ibid.*, **13**, 531 (1911).

[9] Staley, "Ground Coat Enamels for Cast Iron," *J. Am. Ceram. Soc.*, **1**, 99 (1918).

[10] R. E. Brown, "Replacement of Tin Oxide by Antimony Oxide in Enamels for Cast Iron," *Trans. Am. Ceram. Soc.*, **14**, 740 (1912).

[11] Shaw, "Antimony Oxide as an Opacifier in Cast Iron Enamels," *J. Am. Ceram. Soc.*, **1**, 502 (1918).

[12] Staley-Fisher, "Leadless Enamels," *Trans. Am. Ceram. Soc.*, **15**, 620 (1913).

[13] Staley, "Antimony Compounds as Opacifiers in Enamels," *Ibid.*, **17**, 173 (1915).

a thorough treatment, somewhat similar to the mixing of large batches of concrete.

TABLE I.

Batch Formulas.

Raw materials.	No. 1. Steel ground coat.[a]	No. 2. Steel cover, white.[b]	No. 3. Cast iron ground coat.	No. 4. Cast iron cover, white.[c]
Soda	74	...	...	71
Borax	356	154	288	133
Saltpeter	...	65	16	...
Chili saltpeter	...	...	...	24
Lead oxide	...	...	...	144
Zinc oxide	...	...	...	44
Tin oxide	...	...	...	73
Calcspar	...	65	...	24
Barium carbonate	...	...	...	11
Magnesium carbonate	...	10	...	...
Feldspar	363	386	...	372
Fluorspar	53	13	...	107
Cryolite	...	117	...	...
Quartz	144	190	700	...
Manganese dioxide	$6^1/_2$	...	...	...
Cobalt oxide	$2^1/_4$	...	...	...
Mill additions	6% clay 2.5% borax	12% Tin oxide 7% clay $^1/_4$% Mg oxide	9% Sand 12% clay	None

[a] *Trans. Am. Ceram. Soc.*, **14**, 759 (1912).
[b] *Ibid.*, **14**, 498 (1912).
[c] *Ibid.*, **15**, 622 (1913).

The raw batch is introduced into what is termed a "smelting furnace" which is essentially a reverberatory furnace. Reactions take place on the hearth of the smelter involving the various thermal decompositions and combinations characteristic of the particular raw materials involved.[1] After the enamel has been reduced to a uniform fusion the furnace is tapped and the charge run into a trough of cold water, resulting in a thorough shattering

[1] Poste-Rice, "Effect of the Degree of Smelting upon the Properties of a Frit," *J. Am. Ceram. Soc.*, **1**, 221 (1918).

of the product giving a material known as "frit." It is customary to assume in the composition of this frit that the amounts of the various non-volatile oxides involved in the original batch have entered into a combination which is expressed in terms of the molecular weights of the component parts by what is known as the "molecular formula." In Table 2 will be found the molecular formulas of batches given in the first part.

TABLE 2.

Molecular Formulas.

	No. 1. Steel ground coat.	No. 2. Steel cover, white.	No. 3. Cast iron ground coat.	No. 4. Cast iron cover, white.
Na_2O	0.64	0.50	.....	0.30
K_2O	0.08	0.18	.....	0.09
CaO	0.24	0.28	.....	0.35
BaO	..	..	.....	0.01
MgO	..	0.04	.....	..
PbO	..	..	.....	0.13
ZnO	..	..	.....	0.12
MnO	0.03	..	.....	..
CoO	0.01	..	.....	..
Al_2O_3	0.20	0.30	.....	0.15
SiO_2	2.26	2.51	.....	0.86
B_2O_3	0.63	0.26	.....	0.15
F_2	0.23	0.60	.....	0.30
SnO_2	..	..	.....	0.10

As a matter of fact it has been found that, while the actual composition of the frit approaches the theoretical composition as expressed by the molecular formula, there are actually variations depending largely upon the degree of smelting. The more volatile materials such as soda, potash and boric oxide are driven off to a greater or less extent and the result is that the composition of the final frit is lower in these materials than theoretically called for.[1]

There is an exception to the above general scheme of smelting which involves the processing of one type of cast iron ground coat. In this particular case the raw materials are thoroughly mixed but instead of being fused to a liquid state on a smelter

[1] *Loc. cit., J. Am. Ceram. Soc.*, 1, 221 (1918).

hearth they are placed in a cast iron tray and heated to a bright red and thoroughly stirred at intervals. The result is a sintered mass closely resembling pumice stone. This must be further reduced by crushing before being ground for application to the ware.

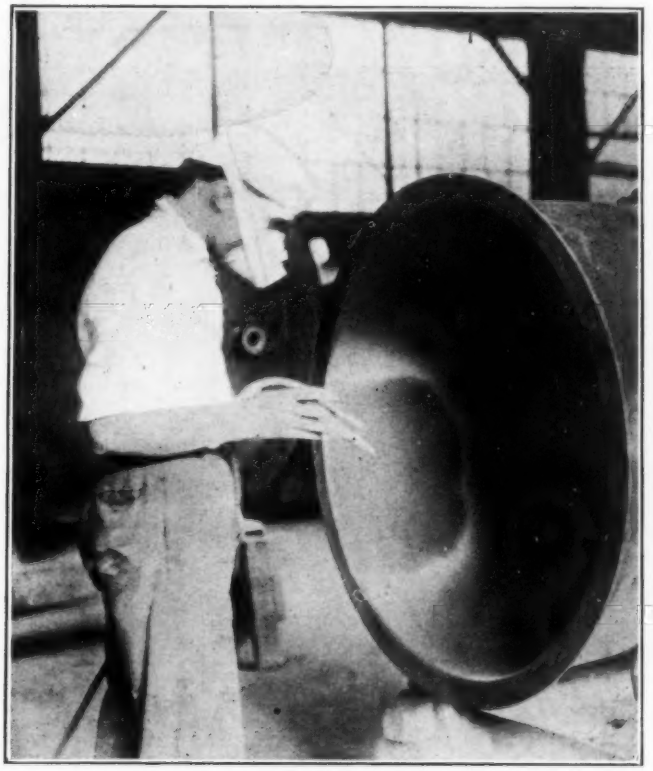

FIG. 5.—Spraying a steel tank.

The next step in the processing of the enamel is the grinding, which may be accomplished either wet or dry. While there are variations to the general statement, we will assume that the wet grinding is for steel enamels and cast iron ground coats only, and dry grinding for cast iron cover coats.

In the wet grinding of the enamel the object is to secure a suspension of the enamel in a finely ground condition so that it may be treated essentially as a liquid. This is accomplished by grinding in a pebble mill a certain amount of frit in the presence of a fixed amount of water and various other mill additions. A necessary material is clay, which has the property of holding the enamel particles in suspension and is susceptible to further

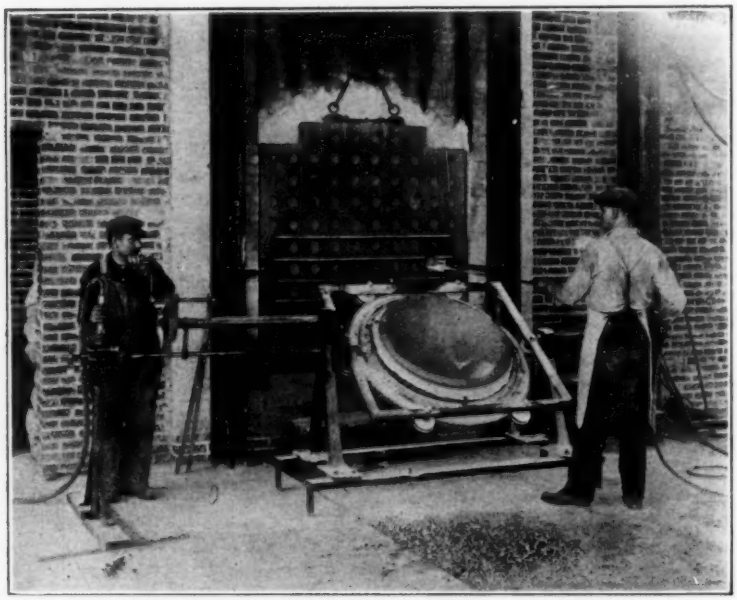

FIG. 6.—Dredging a cast iron dish.

treatment termed "setting up" rendering the suspension particularly stable.[1,2] In the grinding of steel ground coats and some other types of enamel, clay forms the only mill addition, but to produce various colors, materials are often added in the mill which accomplish the desired results. For instance, in the manufacture of white enamel for cooking ware, the customary mill addition is tin oxide.

[1] *Loc. cit., Eighth International Congress Applied Chemistry,* **25,** 317.

[2] Shaw, "American Clays for Floating Enamels," *Trans. Am. Ceram. Soc.,* **19,** 339 (1917).

In some cases it is desirable to control the melting point of the enamel on the ware by adding refractory materials, such as silica or feldspar, in the mill. It is further a frequent practice to introduce into the mill a small amount of material to accomplish the "setting up" of the enamel, further reference to which will be made later. Magnesium oxide and borax are substances frequently used at this stage. In the above table of formulas the various mill additions are given.

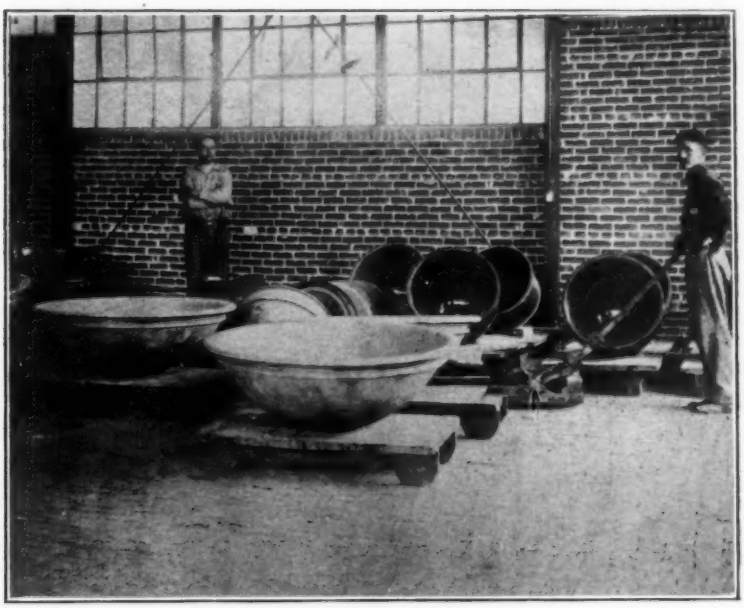

FIG. 7.—Cast iron pieces in process.

After the enamel has been properly ground it is drawn from the mill and stored in containers ready for delivery to the enameling department.

Application.

Steel.—A further treatment will be necessary before the enamel is ready for application to the ware. If the enamel, as it comes from the mill, is diluted to the proper consistency for application,

the suspending power of clay will not be sufficient to prevent settling but if an electrolyte be added in proper amounts a very definite change in the physical properties of the suspension will take place, making it possible to vary the consistency of the enamel through quite a large range without causing settling. A material added for this purpose is termed a "vehicle" and several compounds are used. Rather common practice involves the use of borax for "setting up" the ground coat and magnesium sulphate for the cover coat.[1]

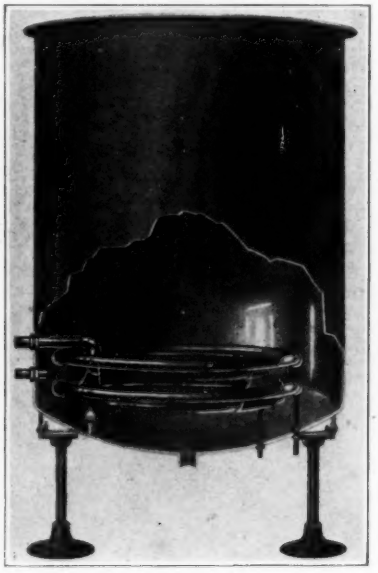

FIG. 8.—Open-top tank with heating coil.

The enamel may be applied to the ware in one of several ways. If the shapes are small and are to be enameled on both sides they may be "dipped" into a relatively large tub of the prepared enamel, the excess enamel being shaken off and the piece rapidly dried. If the enamel is to be applied to but one side it may be poured over the surface which is held at a proper angle so that the excess drains off. This is termed "slushing." In cases where

[1] *Loc. cit., Trans. Am. Ceram. Soc.*, **19**, 339 (1917).

dipping or slushing would be impractical "spraying," which consists essentially of spraying the enamel by means of a compressed air atomizer, is resorted to. This method of application is the one used in the manufacture of steel apparatus of large dimensions.

Burning.

Steel.—After the ground coat has been applied and dried the ware is ready for burning which is accomplished in a furnace, the temperature of which ranges from 1600° to 2200° F., depending

FIG. 9.—Plain closed-top tank, with off-center agitator.

upon the particular type of ware and enamel being burned. A given ground coat requires a higher temperature than the cover coat which is applied to it, and pieces made of heavy metal call for higher temperatures than pieces made of light metal.

Furnaces may be classified as "muffle" furnaces or "direct fire" furnaces, the essential difference being that in the former case the ware is placed in an inner chamber which is surrounded

by the products of combustion while in the latter the products of combustion actually come in contact with the ware being burned. The first type of furnace is generally used in the manufacture of cooking ware and other small pieces while the direct-fire furnace is commonly employed in the manufacture of larger apparatus.

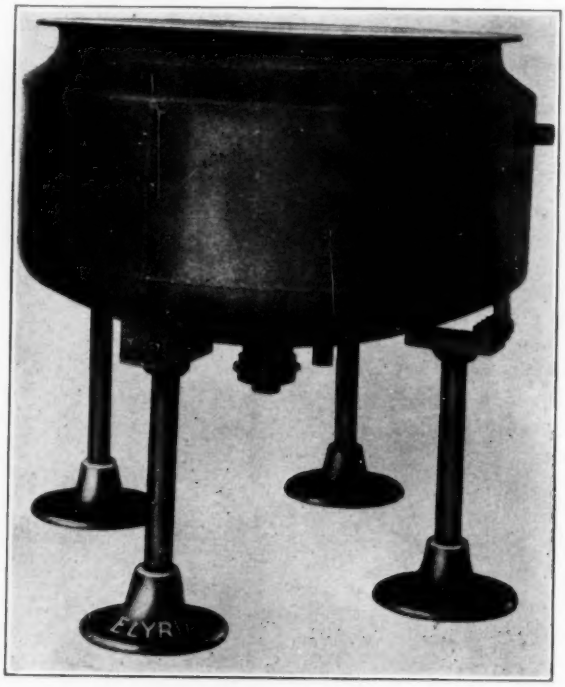

FIG. 10.—Jacketed open-top tank.

When a piece of ware is placed in the furnace certain preliminary reactions take place, such as the dehydration of the clay and any other mill additions which in drying may have retained moisture. The individual particles of the enamel then melt and run together forming the finished surface. After the ground coat has been burned and allowed to cool another cover coat is

applied in a similar manner, dried and burned and the process repeated until the desired amount of enamel has been applied.

FIG. 11.—Jacketed closed-top tank with high speed side agitator.

In the case of steel apparatus the piece is now ready for assembling which may involve the attachment of the supports or per-

haps the fastening on of the steam jacket and equipping with agitators, thermometers, pressure gauges, relief valves and other accessories.

Cast Iron.—In the enameling of the cast iron shapes a ground coat is applied, generally by slushing for sanitary ware and by spraying for apparatus. This coat is thoroughly dried and the ware is placed in a muffle furnace and brought up to a uniform temperature approaching a bright red. In the case of the sintered

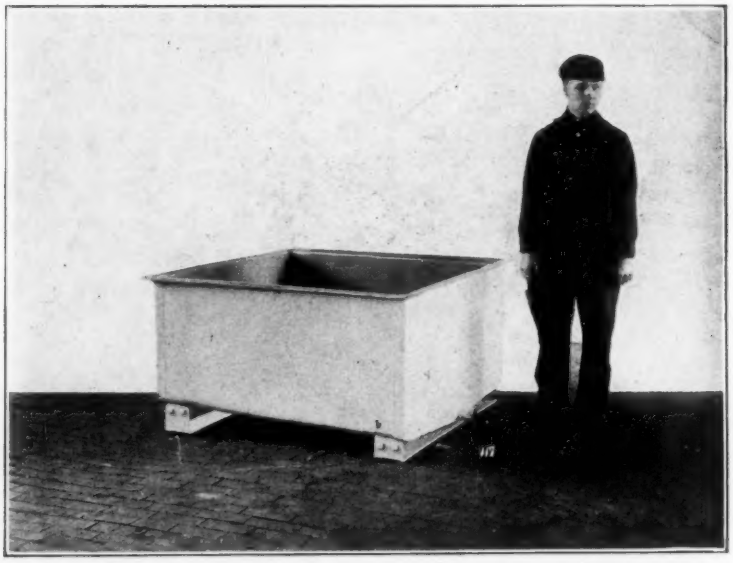

FIG. 12.—Rectangular tank.

ground coat the ware at this point if allowed to cool would present a rough surface while in the case of a fritted ground coat the enamel would be glossy.

However, the piece is not permitted to cool when withdrawn from the furnace. The enamel to be applied has been ground to a very fine dry powder by placing the dry frit in a mill and grinding without mill additions. The proper amount of this fine powder is placed on a sieve which, together with a handle and vibrator operated either by compressed air or electricity, is

termed a "dredge." By the use of this piece of apparatus the fine powder is shaken on the hot surface of the ware, which, after being withdrawn from the furnace, has been placed on a "turn table." This machine is so constructed that ware placed on it can be rotated and tipped up and down to any position. After a proper amount of the enamel has been applied to the revolving piece it is run back into the furnace and allowed to come to a sufficient temperature to fuse the enamel down to a fairly uniform coat. The piece is drawn out and another layer of enamel applied, put back into the furnace and burned down and the

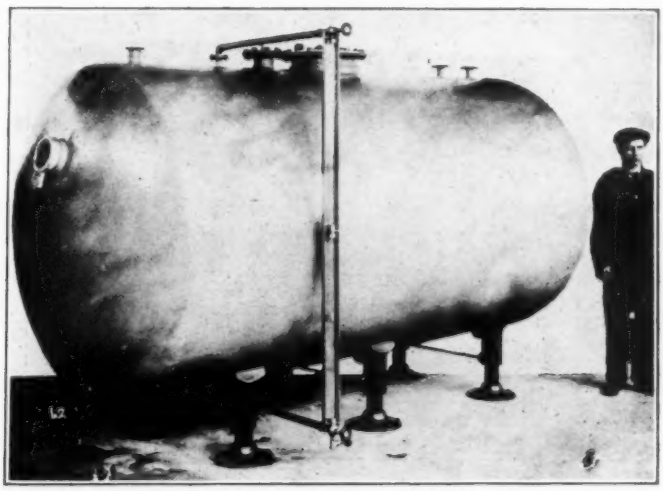

FIG. 13.—Horizontal storage tank.

operation repeated until the desired thickness is produced, after which it is given a firing somewhat harder than the previous ones, the result being a very smooth surface with a high gloss.

The piece of ware thus processed is ready for assembling, which may involve any or all of the operations referred to in connection with the assembling of the steel apparatus, depending upon the form of equipment being made, which may range from an unjacketed, open-top dish to a jacketed, vacuum pan with agitator and other accessories.

Uses of Enameled Wares.

The uses to which enamel lined apparatus are put cover a large field ranging from the mild conditions characteristic of the dairy industries to such severe chemical conditions as dilute mineral acid. In general the steel apparatus, available in much larger units than the cast iron, finds its application under the milder conditions while the cast iron apparatus, enameled with an entirely different formula, proves of service under the more extreme conditions.

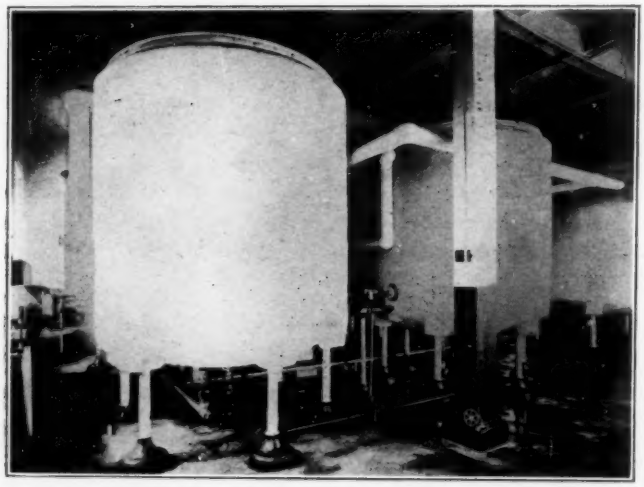

FIG. 14.—Six 2500 gallon tanks for milk storage.

The actual construction of the steel apparatus may include tanks up to ten feet in diameter and about twelve feet in length, which may be either open or closed top, jacketed or unjacketed, with or without agitator, the design varying to meet the particular conditions involved.

In dairy operations there are a great many uses for this line of material, such as holding and cooling of milk and aging of ice cream, while in the canning and other food preparation industries there are various forms of cooking kettles, vacuum pans and

storage units. In pharmaceutical work this line of equipment is very efficient for the mixing and storage of various preparations.

The cast iron equipment, available in the form of shallow dishes and pans, open-top kettles, jacketed or unjacketed, stills, vacuum pans and digestors, is used primarily in connection with the pharmaceutical and chemical industries where conditions are such as to render it impossible to carry on the desired processes in contact with metal.

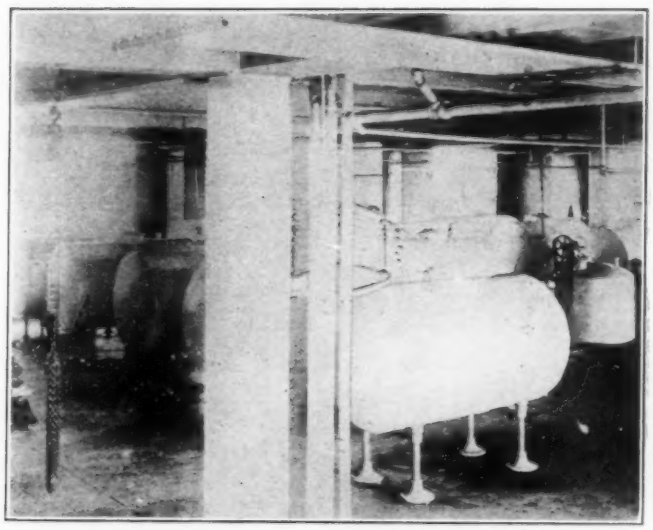

FIG. 15.—Storage of pharmaceutical preparations.

Technical Control.

It would be quite impossible to enumerate all of the features of the technical control of an enameling operation. Of prime importance in all cases is the quality of the raw materials which are being used. The steel should be a basic open hearth steel of low carbon content and in such mechanical condition that it will not develop cracks or other imperfections which will cause corresponding defects in the enamel. The cast iron should be a good quality of gray iron free from mechanical defects.

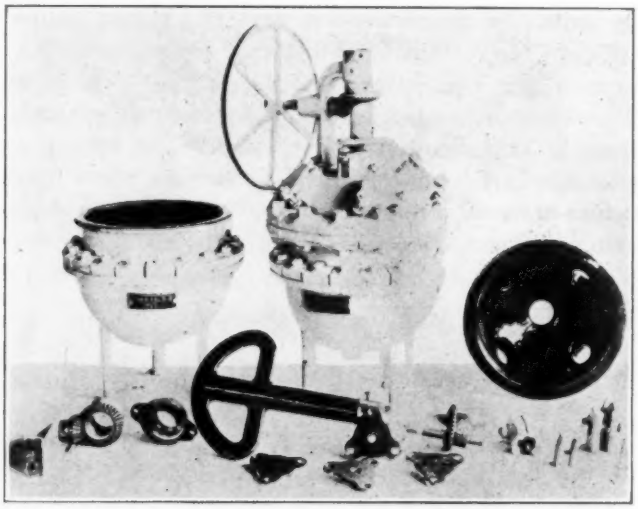

FIG. 16.—Cast iron laboratory autoclave.

FIG. 17.—Cast iron still with agitator and accessories.

Uniformity of raw materials for the enamel or correction of formulas in the case of irregularities are fundamental if the product is to be uniform. This necessitates an analysis of the raw materials.[1,2] A failure to appreciate the possible variations of raw materials and the consequent results are a very serious matters. As an extreme case we know of a particular instance in which an enameler was using borax which had been stored in bags quite close to a furnace. The theoretical composition of borax and the composition which will be quite closely approached

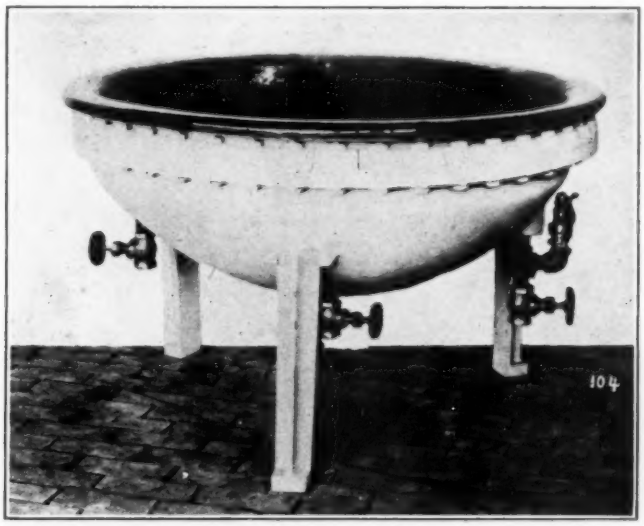

FIG. 18.—42″ jacketed cast iron evaporating dish.

under normal storage conditions is approximately 53 per cent sodium tetraborate, the balance being water of crystallization. In the case noted the sodium tetraborate figure ran very close to 70 per cent. In other words, for every 100 lbs. of borax taken, 70 lbs. of sodium tetraborate were introduced rather than 53 lbs. At this particular time the enamel was running very soft and overburned very readily. The explanation is obvious.

[1] Landrum, "Methods of Analysis for Enamels and Raw Materials," *Trans. Am. Ceram. Soc.*, **12**, 144 (1910).

[2] J. W. Mellor, "Treatise on the Ceramic Industries," Vol. 1.

The materials which are particularly subject to variations in composition and which, at the same time, enter into all enamel

FIG. 19.—Cast iron open-top boiling kettle.

batches in considerable quantities are soda, borax, and feldspar. As has been pointed out, the borax is susceptible to the loss of

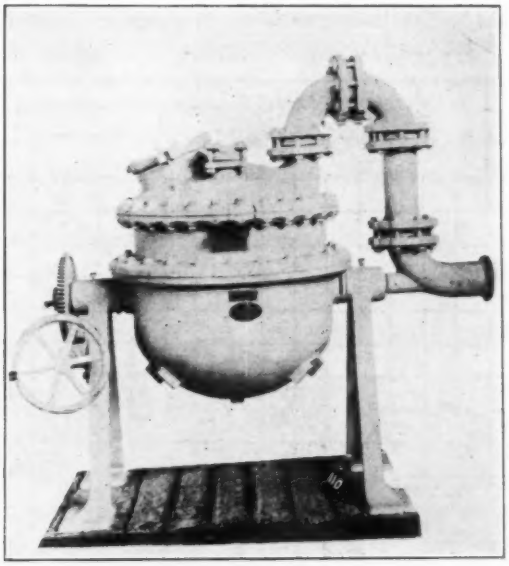

FIG. 20.—Cast iron jacketed closed-top tilting kettle with fume vent.

FIG. 21.—Group of various cast iron apparatus.

moisture and it has been found experimentally that when stored under very dry and warm conditions the water of hydration

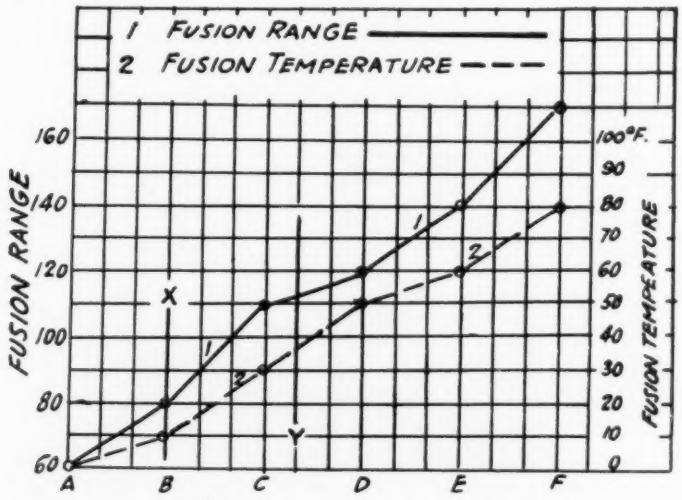

FIG. 22.—Increase of deformation range and rise of deformation temperature produced by continued smelting.

which should be present to the equivalent of 10 molecules of water can be reduced to 5 molecules of water and this lower

FIG. 23.—Underburned enamel. (75 diameters.)

hydrate, exposed to the atmosphere, will again take up the 5 molecules of water approaching the theoretical borax composition.

Sodium carbonate will absorb moisture and carbon dioxide from the air so that in some cases a greater weight than that theoretically called for must be taken to introduce a given amount of soda.

Feldspar may vary quite materially in the alkalies and again will contain as an impurity various amounts of free silica, a difference which may make quite radical variations in the enamel. Based on the same specified quality of feldspar we have received

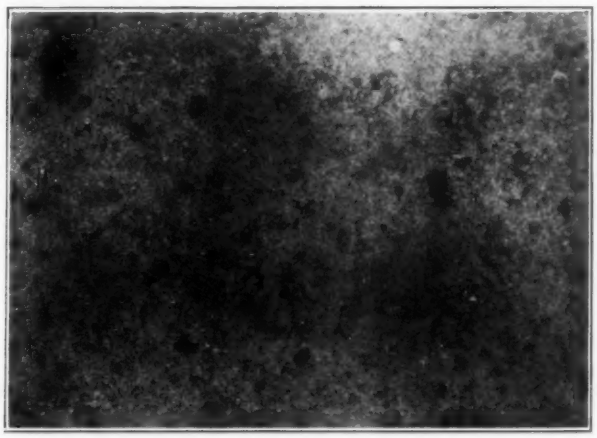

FIG. 24.—Normal burned enamel. (75 diameters.)

material ranging from 65 to 75 per cent silica, an irregularity which, if neglected, will cause rather radical differences in the final product.

The matter of smelting, grinding and burning are details which must be controlled somewhat differently under one set of conditions than under another. In other words, those in charge must become familiar with the particular type of enamel, determining what particular degree of smelting, fineness of grinding and burning temperatures produce the best results. The use of

definite fineness tests and accurate temperature control are quite essential if uniformity is to be realized.

The properties of the final enamel, both physical and chemical, are points which have to do with its service in the field and are properties which are very often tested.

There are various physical properties both of the frit and the final enamel which are worthy of attention and which may vary through wide ranges with a given formula if not properly processed. Under- or oversmelting will produce radical differences as to the fusion[1] temperature of a given formula and over- or

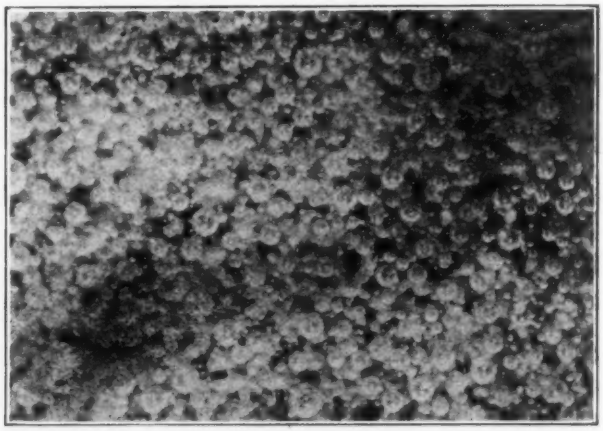

FIG. 25.—Overburned enamel. (75 diameters.)

underburning will produce irregularities both as to the actual nature of the surface exposed and the ability of the enamel to adhere to the metal.

The underburned enamel when examined under the microscope will show a rather irregular condition involving the presence of unfused particles while the overburned condition will show a very serious tendency toward the formation of large bubbles. The intermediate stage approximating the proper burn will show practically no unfused material and the first appearance of fine bubbles.[2]

[1] *Loc. cit., J. Am. Ceram. Soc.*, **1**, 221 (1918).

[2] Poste, "Enamel Surfaces under the Microscope," *Trans. Am. Ceram. Soc.*, **19**, 146 (1917).

The ability of the enamel to adhere to the metal under mechanical abuse has been the subject of various methods of testing, none of which can be taken as entirely satisfactory.[1] There are three different conditions which should be considered in a me-

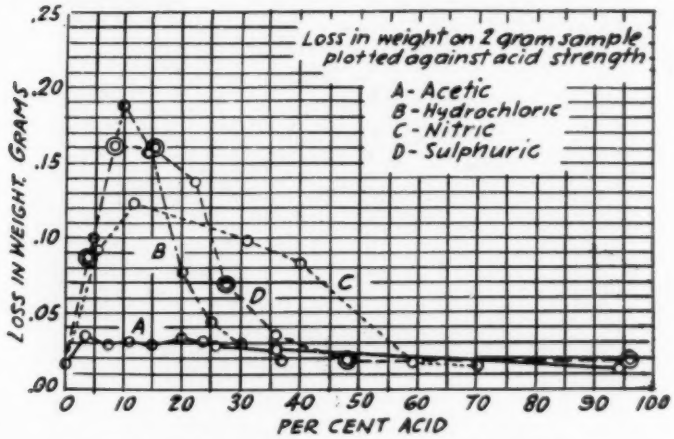

Fig. 26.—Relative activity of acids on enamel.

chanical test of the impact type. The blow on the enameled surface may not be sufficient to deflect the steel in which case it amounts to a crushing or pulverizing test of the enamel itself. The blow may be sufficiently severe to cause a momentary de-

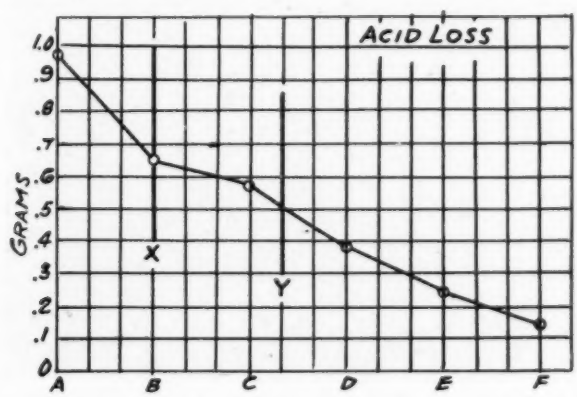

FIG. 27.—Decrease of activity of acid on enamel with continued smelting.

[1] *Loc. cit.*, *Trans. Am. Ceram. Soc.*, 14, 489 (1912).

flection of the steel within its elastic limit following which the steel will resume its normal position without setting up permanent

FIG. 28.—Underburned enamel after etching with acid (75 diameters.)

strains in the metal although there may be a failure of the enamel. Or the steel may be deflected beyond the elastic limit giving a

FIG. 29.—Normal burned enamel after etching with acid. (75 diameters.)

permanent deformation in which case the relation of the enamel to the steel is materially different from under either of the other conditions.

A chemical property of the enamel which is a matter of prime importance is its ability to withstand the corrosive or solvent action of the substances with which it is to come in contact, and especially in connection with apparatus to be used in the chemical industries. There are various means of determining and comparing the resistance of enamels to such action some of them having to do with the frit[1,2,3] and others with the final ware.[4]

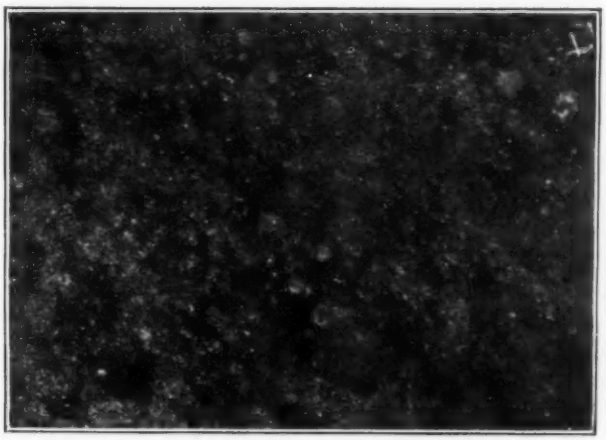

FIG. 30.—Overburned enamel after etching with acid. (75 diameters.)

It is quite evident from the work that has been done that no satisfactory method exists which will enable various people under different conditions to obtain comparative results and the Committee of Standards of the American Ceramic Society has

[1] Poste, "The Relative Action of the Acids on Enamel," *Trans. Am. Ceram. Soc.*, **17**, 137 (1915); "The Relative Action of the Acids on Enamel," *Ibid.*, **18**, 762–926 (1916); "The Relative Action of the Acids on Enamel," *J. Am. Ceram. Soc.*, **2**, 32 (1919).

[2] Frost, "Action of Acetic Acid Solutions of Different Strengths on Sheet Steel Enamel," *J. Am. Ceram. Soc.*, **1**, 422 (1918).

[3] Landrum, "The Resistance of Sheet Steel Enamel to Solution by Acetic Acids of Various Strengths," *Trans. Am. Ceram. Soc.*, **13**, 494 (1911).

[4] *Loc. cit.*, *Trans. Am. Ceram. Soc.*, **14**, 489 (1912).

appointed a Sub-Committee on Enamels which is working on this problem at the present time.

FIG. 31.—Mottled cooking ware. (75 diameters.)

In a general way it may be stated that the action of a given acid on an enamel is the stronger the greater the ion concentration

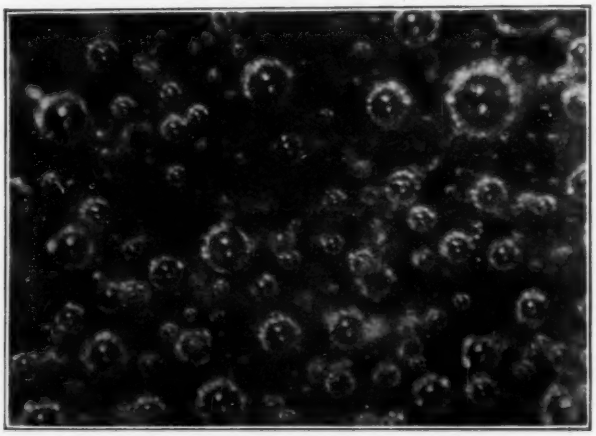

FIG. 32.—Overburned commercial ware. (75 diameters.)

or electrical conductivity of the acid.[1] For example, it is a well-established fact that dilute hydrochloric acid is far more

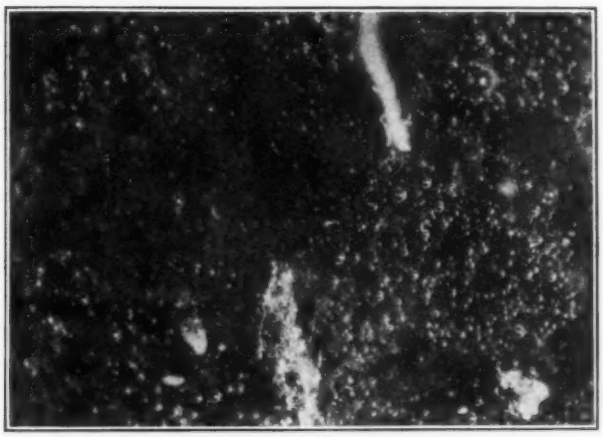

FIG. 33.—Commercial ware. (75 diameters.)

active than concentrated acid. It is very evident that details in processing may materially vary the acid resistance of a given enamel in its final form. In the first place the harder the smelting

Fig. 34.—Very homogeneous commercial ware. (75 diameters.)

[1] *Loc. cit.*

the greater the acid resistance because of a change in the chemical composition of the frit itself. The manner in which the enamel is burned on the ware also has a bearing on its acid resistance. This point has been definitely proven by observing through the microscope enamels which have been under- and overburned and then etched with acid, the overburned enamel having been subject to much more decomposition than the underburned, probably as a result of the different physical conditions existing at the surface due to the formation of large bubbles previously mentioned.[1]

The question of under- and overburning as affecting the final conditions of the enamel suggests noting the result of the examination of several pieces of commercial ware under the microscope, all magnified to the same diameter. Fig. 31 is a microphotograph of a mottled cooking ware enamel; Fig. 32 a commercial enamel which was apparently seriously overburned; Fig. 33 another piece of commercial ware; and Fig. 34 an exceptionally uniform commercial ware.

ELYRIA ENAMELED PRODUCTS CO.,
ELYRIA, OHIO.

[1] *Loc. cit., Trans. Am. Ceram. Soc.*, **19**, 146 (1917).

COMPARISON TESTS FOR STRIAE IN OPTICAL GLASS, BY THE BRASHEAR CONVERGING LIGHT, DIRECT VIEW METHOD, THE BUREAU OF STANDARDS TANK IMMERSION METHOD, AND THE SHORT RANGE PROJECTION METHOD.[1]

By L. E. Dodd.

I. Introduction.

A study of the manner in which light transmitted through optical glass is able to make visible the striae so often present in it as a very important defect, leads to the conclusion that the visibility of the striae is highest where the light, assumed to be of suitable intensity, issues from the most concentrated source (so-called "point source") and is moreover monochromatic. Of the two requirements, concentrated source and monochromatism, the former would appear to be in general the more necessary until the source has reached the last stage of practicable concentration. In this last statement the question is omitted of obtaining a "match" between the liquid and the glass in an immersion method.

It has been common practice to employ a line source for purposes of striae detection, and this is no doubt practicable, if not so precise, where the glass sample under test can be freely turned so that it may be observed with the light passing through it in any desired direction. But the line source, as contrasted with a point source, is concentrated only relative to its own transverse direction, for in its own plane containing the eye of the observer—supposing the line source to be perpendicular to the line of sight—it is an extended source and acts as such. The result is non-uniform visibility of the striae in the sample, for only those components parallel to the line source are revealed distinctly, while the remainder, for the same position of the sample, are partially or wholly obscured.

[1] By permission of the Director, Bureau of Standards.

Although a turning of the piece of glass during inspection makes the line source method practicable to a certain degree, an absolutely free turning to permit the light to pass through the sample in many successively different directions is not so practicable for routine testing on account of the time required. The conditions of uniform visibility afforded by a point source are therefore desirable, so that for a given position of the sample the maximum number of parts of striae present can be seen. Although even with a point source some turning of the sample may still be necessary because of the lack of symmetry of the striae as to both their shape and orientation relative to the source, the amount of such turning should be considerably lessened where one of the conditions requiring it has been removed.

Given, then, a truly concentrated source of suitable intensity and in addition monochromatic light, the illumination is ideal for striae testing. The various possible methods of such testing belong to one or the other of two general types, what may be termed the direct view type, and the projection type. In the former the glass sample is viewed directly either with the unaided eye or with telescope or microscope, and in the latter type the light, which may be parallel, convergent, or divergent as it passes through the sample, is intercepted, after transmission through the glass, at either an opaque or a translucent screen, where a shadow pattern of the striae is formed and there viewed by the observer. Photography as it has been applied to exhibit striae in glass is to be included probably in all cases in the projection class.

Object of the Present Work.

In view of the more concentrated filaments in electric lamps of recent manufacture it has appeared that the projection method might readily be applied, at least for polished samples, to short ranges in a compact apparatus having neither prisms nor lenses. Such an apparatus would consist of three parts, light source, stand or other support for the glass sample, and projection screen. It seemed likely that its total length could be made only a foot or less. It was proposed to use a translucent screen. By this device the striae shadow patterns, or images, could be viewed by the observer from that side of the screen away from the sample

and the light source, thus reducing the space necessary for the apparatus while still keeping the position of the sample during inspection within easy reach of the observer. It was also proposed to test this method with white light illumination.

The primary object of the present work therefore has been to learn something definite of the possibilities of the short range projection method for detecting striae in optical glass. It was thought that one of the best ways to accomplish this would be by means of a comparison of striae methods in a test series carried out so that some thoroughness could be attributed to the work, sufficient at any rate to make the conclusions reliable.

Plan of the Work.

In order to make with more thoroughness a test of the general method of short-range projection, a number of series of comparison tests, five in all, were performed. For this purpose there was provided a number of glass samples regarded as large enough for a fair test. Thus 117 samples comprised the test set. The same set was used in each of the five series. These five comparison tests, each giving its own data, required four different set-ups of apparatus, employing, respectively, the Brashear[1] converging light, direct view method, the modified tank immersion method of the Bureau of Standards, and the short range projection method. The Bureau of Standards tank immersion apparatus was used with the samples both in the polished and the rough-ground states. The tank alone of this apparatus was used also with the short range projection method where the samples had ground surfaces.

The experimental arrangements are described later in this paper. By permission of Mr. J. B. McDowell the Brashear apparatus was employed for the first series, since it was readily available for comparison purposes and would serve to check the S. R. P. method and the T. I. method, as the latter has been regularly operated by the Bureau. It was used at the Brashear plant and was apparatus that had been employed there for some time. At that plant there is used also for precision test for

[1] By the "Brashear" method is here meant the direct view, convergent light method for striae testing as used with telescope objective by Brashear.

striae of large blocks of glass a spherical mirror method, into the merits of which the present work has not gone. The tank immersion apparatus of these tests was the one which has been in regular use by the government during the past seven or eight months, for routine testing in the optical glass factory at the Pittsburgh Branch of the Bureau of Standards. Apparatus for the S. R. P. method was set up at that plant.

Apparatus

The accompanying diagrams (Fig. 1) with legends may suffice for description of the experimental arrangements and illumination systems. Information with reference to the five comparative test series is tabulated below. A somewhat detailed verbal description of the light source and the translucent screen of the S. R. P. apparatus in the present work, and of the manner in which it is used, will be included under this head.

It is to be noted that tank immersion is merely an adjunct to either of the two general types of striae testing apparatus, being necessary where the glass surfaces are unpolished, to eliminate surface markings by making them invisible. This is accomplished by obtaining a "match" of indices of glass and liquid for the particular wave length of the monochromatic light used. Where the light is not monochromatic a perfect match cannot, of course, be obtained.

Description of S. R. P. Apparatus.—The two essential parts of the short range projection method are: (1) the light source; and (2) the translucent screen to receive the striae shadow patterns.

(1) **The Light Source.**—As previously stated, light conditions for revealing the presence of striae are most favorable when the source is as concentrated as possible. To avoid focusing light rays on a pinhole aperture in an opaque screen, and also the disadvantage both of the wandering of the spot of maximum brightness and of a considerable lack of concentration where an ordinary electric arc is employed directly without a lens, a small commercial type electric lamp of more recent design and of unusual concentration was used. The specifications of this lamp are as follows: type, motorcycle, trade name, Edison Mazda 131; con-

E—eye position.

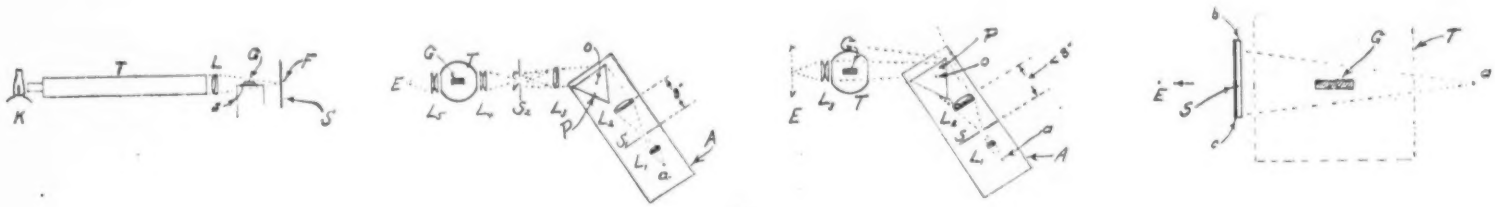

FIG. 1.

(*a*)

Converging Light, Direct View Method of Brashear, employing telescope.
(Vertical longitudinal section.)

K—kerosene flame.
T—4½ ft. telescope with 4 in. objective.
L—achromatic objective, 4 in. diam. and focus about 20 in.
G—glass sample.
s—stop for sample.
S—cross-section of opaque screen placed perpendicular to line of sight.
F—focus of rays at edge of screen, also eye position.

(*b*)

Unmodified Tank Immersion Method, Bureau of Standards.
(Horizontal long. sec.)

a—16-v. lamp source, inverted "U" filament.
L_1—achromat, about 2 in. diam. and 2 in. focus.
S_1—screen with pinhole permitting a short segment of image of "U" filament to act as "point source."
L_2—achromat, 5 in. diam., 8 in. focus.
P—carbon bisulphide prism.
A—support for rotating the parts above named as unit, with axis as at point *o*.
L_3—achromat, same dimensions as L_2.
S_2—screen with slit ⊥ plane of paper.
r and *v*—limits of visible spectrum on screen S_2.
L_4, L_5—converging lenses, 5 in. diam. and 8 in. focus.
I—immersion tank with plate glass windows.
G—glass sample.
E—eye position.

(*c*)

Modified Tank Immersion Method, Bureau of Standards.
(Horizontal long. sec.)

Note—the parts mounted as unit on support *A* are the same and have the same relations here as in Fig. 1 (b), except that the distance from S_1 to L_2 is slightly less than the focal lenth of L_2, so that the beam is somewhat divergent from L_2 to L_3.
T—tank.
G—glass sample.
L_3—uncorrected converging lens, 5 in. diam., 8 in. focus.
E—eye position at focus of spectrum.
r and *v*—limits of visible spectrum. (Not all of spectrum was focussed at *E* at one time. The segment present at one time depended on the angular position of support *A*.)

(*d*)

Short Range Projection Method
(Horizontal sec. in line of sight.)

a— 6- to 8-v. lamp, concentrated filament (see separate description).
T—position of tank in immersion test on samples having ground surfaces.
G—glass sample.
S—translucent screen.
b—crystal glass of screens.
c—opal backing of screen *S*.
E—eye position.

DESCRIPTIVE.

Test series.	Apparatus.	Method No.	Type.	State of samples with each method.	Remarks.
1.....	Brashear (Fig. *a*)	I	Direct view	Polished	
2.....	B. S. tank immersion (Fig. *c*)	II	Direct view	Polished	
3.....	Short range projection (Fig. *d*)	III	Projection	Polished	Without tank. Lower light intensity (see discussion).
(3*a*)...	S. R. P. (Fig. *d*)	III	Projection	Polished	Without tank. Light intensity increased from that in Series 3. Series incomplete owing to most of the samples having just previously been ground on the polished ends.
4.....	S. R. P.	IV	Projection	Ground	With tank. Increased light intensity as with Series (3*a*).
5.....	B. S. T. I. (Fig. *c*)	V	Direct view	Ground	

tact, single; volts, 6–8 amps., 3.5; c. p., 28; type of filament, "C" (see Fig. 2 and description below); diam. of spherical bulb, $1\frac{1}{9}$ ins.

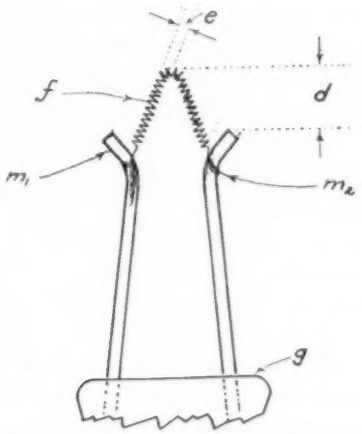

Fig. 2.—Concentrated filament. Axis of beam in plane of paper.
f—tungsten filament soldered to metal supports, m_1, m_2.
d—effective length (about $^3/_{32}$ in.) of filament as lamp was used in S. R. P. method.
e—width of helix about 1 mm.
g—glass support.

Filament.—The type "C" filament is of tungsten wire in the form of a helix of about 1 mm. outside diameter (Fig. 2). The helix itself is bent into a V-shape, with vertex pointing away from the base of the lamp. The lamp was adapted base downward with the plane of the V parallel to the line of sight, or the direction including source, glass sample, and translucent screen. Thus the filament afforded essentially a very short "line source," with some width (about $^1/_2$ mm.), and of about $^3/_{32}$ inch length. While this filament provided a source of by no means so great concentration as that of a luminous pinhole, the results obtained with it in the present tests are favorable to the adoption of an electric lamp, with its advantages in use, for striae testing, or wherever light source concentration of moderate intensity is desired. The present results justify further concentration of

filament with the maintenance of good light intensity, in developmental work on such lamps, for "point source" purposes.

(2) **The Translucent Screen.**—While a thin sheet of any light-colored translucent material that diffuses light well enough to prevent direct vision of the source through it, will show the striae shadow patterns, the visibility as far as the screen itself affects it, is a maximum when the translucent material is perfectly free from visible structure, or grain. Otherwise the finer striae, especially if they are very limited in extent, may be partially or wholly obscured, depending upon the nature and coarseness of this structure in the screen. If it were not for its grain a sheet of ordinary white paper would serve the purpose even of the most precise inspection.

Ground glass is objectionable on the same grounds of showing grain, either of line or of strictly granular type according to the manner of grinding. Whether a sheet of glass can be so finely ground as to eliminate serious visible markings on the ground surface and still maintain enough diffusing power to form sharp shadow patterns of the finer striae remains to be determined.

For the short range projection method in the present tests a very satisfactory translucent screen was fortunately obtained[1] that appears to meet the conditions. Indeed, it is not certain that this screen could be materially improved upon for the purpose. Its only possible defect as a screen for the S. R. P. method is in the minor question, possessing some uncertainty, of the desirability of absolute whiteness in such a screen. It was in the form of a plate of crystal glass with opal backing. In dimensions the crystal glass was approximately $1^5/_6 \times 2^1/_2$ inches, and 2 mm. thick, while the opal backing ran about $^1/_4$ mm. in thickness. There was no visible structure in the opal glass. This screen was adapted in the S. R. P. method with the opal backing always nearest the eye of the observer.

Dimensions and Procedure, S. R. P. Apparatus.—In the present tests with glass samples having polished surfaces, a given sample was laid on a table top at a distance of about 6 or 8 inches from the light source and on a level with it, and the screen was

[1] This screen was placed at the disposal of the Bureau by the Consolidated Lamp and Glass Co., of Coraopolis, Pa., through the courtesy of Mr. Sargent.

held in the hand, with its edge supported on the table, at a distance of from nothing up to 6 or 8 inches at the most. In the tests with the tank in place (Series 4) the screen was fixed in position in a sheet of cardboard that covered the plate glass window of the tank opposite the source, and the distance from sample to screen was about $4^1/_2$ inches (to center of sample), while the distance from source to sample was about the same as before.

It is to be noted that in both series (3 and 4) where the S. R. P. method was used, the striae shadow patterns were formed with white light, for it was desired to test the method without the use of prisms or lenses. Liquid filters, to make the light from the electric lamp approximately monochromatic, appear to be undesirable because of their serious reduction of the intensity, although the possible use of some sort of color screen with this method doubtless merits further investigation. A satisfactory color screen would of course add to the value of the method.

Description of Samples.

The set of 117 samples were of borosilicate crown glass, of approximate index 1.51 to 1.52, made by a commercial optical glass plant for the government's war work. They were the property of the Ordnance Department and were on hand at the Brashear plant at the conclusion of the war work there. By permission this set of samples has been retained by the Bureau of Standards as its own property for further work with them. They were of rectangular prism shape and uniform size, $1.5 \times 1.5 \times 6.5$ cm., with ends polished and side surfaces in the ground state following the trimming down by Brashear's from the original blank as molded by the glass company. In size this original blank was about $2.5 \times 2.5 \times 7$ cm. From the rectangular prisms, such as comprise this test set, as trimmed down from the original blanks the working into the finished rotating prism form was done, chiefly by making the ends of the rectangular prisms oblique and polishing same. Brashear's tested the samples in the rectangular prism form, and it was in this form that the set of 117 was used throughout the five comparison series of the present work.

Experimental Procedure.

In all five series the samples were viewed through the ends, or lengthwise. The ground side surfaces remained unaltered throughout the tests. Judgment as to the grade of each sample in the set was based entirely on the visibility of the striae under these conditions. Samples in which striae could be distinctly seen were not placed in the first grade. The second grade samples contain lighter striae, and the X glass either heavy or numerous light ones. The percentage of X glass (glass rejected as not usable) was used as a relative measure of the "strictness of the grading."

Observer A, Brashear's regular inspector, first graded a number of samples with Method I, taking them as they came from the boxes in which they had been stored. He separated them into three grades, based entirely, in this case, on visible striae, which he designated as "best," or "good," "fair," and "bad." The Bureau inspectors subsequently throughout the tests used the same grading scheme, which corresponds to the Bureau's customary grading, of A and B, C, and X, or rejected, glass.[1]

When observer A had thus graded a number of the blanks regarded as sufficient to form the desired set for the comparative tests, the samples were numbered and A's grading recorded. They were then graded by B, being placed in position in the apparatus for him one at a time, without regard to numerical order, except to have each sample selected from the lot in a random fashion, and with the number of any given sample unknown to him. This plan was followed throughout the tests. Thus the observer could not be biased by his associating the

[1] During the use of the modified tank immersion method for routine grading by the Bureau as to visible striae, no glass was graded A, and only that which appeared to be free from striae was graded B, where formerly glass appearing free from striae was graded A, and that having very faint striae B. This greater strictness had been adopted because of some question as to the effectiveness of the Bureau's immersion method in its modified form, a question of the monochromatism of the light. Since this question was raised no glass tested by this method was graded A. The results of the present work, however, tend to restore confidence in the Bureau's immersion method as modified, which has been in use more recently and up to the present time.

number of a given sample with a previous grading. The only way in which his memory might have entered as a disturbing factor was through recognition of a given sample by the appearance of its striae. But even in this event the effect on the results could not have been serious, as is shown in discussion of this point later.

In the testing of each sample, where the glass was not unquestionably of grade X, it was rotated, if necessary, through at least 90° (with the long axis kept in the line of sight) to avoid error from a certain amount of non-uniform and hence inadequate visibility with the sample in a fixed position. Such non-uniformity was due to the straight edge of the opaque screen at the position of the eye (see description of apparatus). Also when necessary the sample was turned end for end.

When observer B had finished the set of 117 samples—still with Method I in use—it was similarly tested and graded by observer C. The same procedure, but with only the two Bureau observers, B and C, was followed throughout the remaining four series of tests.

Data and Results.

The data and results are assembled in the following tables. Table 1 gives the gradings, Table 2 the totals and percentages, and Table 3 a comparison of the five methods on the basis of the strictness of grading by the Bureau's inspectors.

Discussion.

The data and results as summed up in Table 3 and the diagram of Fig. 3, require comment other than the statements, based upon obvious comparisons, to be found in the conclusions.

Examination of the data in Table 1 shows that observer B graded the same 54 of the set of 117 samples X in all five series, while observer C's corresponding number was 46. The relation between these two numbers is in good correspondence with that between the two observers' gradings throughout the tests. Of the set, the same 40 of the X's were so graded in all five series by both of the observers in common. Of the remaining samples of the set the same 14 that were graded X in all five series by observer B were not so graded in all the series by observer C,

TABLE I.

Data from Comparison Tests for Striae on 117 Samples with Eleven Complete Gradings.

Series	1.									2.				3.				(3a).				4.						5.			
Observer	A			B			C			B			C	B			C	B			C	B			C	B			C		
Grading	1	2	X	1	2	X	1	2	X	1	2	X	1	2	X	1	2	X	1	2	X	1	2	X	1	2	X	1	2	X	1	2	X
Sample.																																	
1		x				x			x			x				x			x								x			x			x
2	x				x			x			x			x			x					x				x			x	x		
3			x			x			x			x	x				x			x					x			x				x
4	x				x			x			x		x				x			x					x	x			x			x
5			x			x			x			x			x		x			x					x			x				x
6			x			x			x			x			x		x			x					x			x				x
7			x			x			x			x			x		x			x					x			x				x
8			x			x			x			x			x		x			x					x			x				x
9		x				x		x				x			x	x			x				x			x			x			x
10	x				x			x			x		x			x			x					x			x	x			x	
1			x			x			x			x			x			x			x					x			x			x
2		x				x			x			x			x			x			x					x			x			x
3			x			x			x			x			x			x			x					x			x			x
4		x				x			x			x			x			x	x							x			x	x		
5	x					x			x		x		x					x			x				x			x				x
6		x				x		x		x			x					x			x					x	x					x
7	x			x			x					x			x	x			x					x			x			x	x		
8	x				x		x				x			x		x			x					x		x			x	x		
9	x				x		x			x			x			x	x			x					x	x			x			
20	x			x			x			x			x			x			x					x			x			x	x		
21			x			x			x			x			x			x			x					x			x			x
2			x			x			x			x		x				x			x					x			x	x		
3			x			x			x			x			x			x			x					x			x			x
4			x			x			x			x			x			x			x					x			x			x
5			x			x			x			x			x			x		x					x			x			x
6			x			x			x			x			x			x			x					x			x			x
7	x					x			x			x			x			x			x					x			x			x
8	x				x		x				x		x			x			x				x			x	x			x		
9	x				x			x				x			x			x					x			x			x			x
30	x					x			x			x			x			x						x			x			x			x

TABLE 1—(*Continued*).

Series	1.									2.				3.				(3a).				4.				5.			
Observer	A			B			C			B		C		B		C		B		C		B		C		B		C	
Grading	1	2	X	1	2	X	1	2	X	1	2	X	1	2	X	1	2	X	1	2	X	1	2	X	1	2	X	1	2	X	1	2	X
Sample.																																	
31			x			x			x			x			x			x			x			x			x			x			x
2			x			x			x			x			x			x			x			x			x			x			x
3			x			x			x			x			x			x			x			x			x			x			x
4	x					x		x			x	x			x	x				x			x			x			x			
5		x				x			x			x	x			x				x			x			x			x			x
6	x			x					x			x			x	x				x			x			x			x			x
7	x					x			x			x	x			x				x			x			x			x			x
8	x				x		x			x			x			x				x			x			x			x			x
9	x				x		x			x			x			x				x			x			x			x			
40	x				x			x		x			x			x					x			x			x			x			
41		x				x			x			x			x			x					x			x			x			
2		x				x			x			x	x			x					x			x			x			x			
3		x				x		x				x			x						x			x			x			x			x
4		x				x			x			x			x						x			x			x			x			x
5		x				x		x		x			x			x					x			x			x			x			
6		x				x			x			x			x						x			x			x			x			x
7	x			x				x				x			x						x			x			x			x			x
8		x				x		x		x			x			x						x			x			x			x		
9		x				x			x			x			x						x			x			x			x			x
50	x					x			x			x	x			x						x			x			x			x			x
51	x					x			x		x		x			x						x			x			x			x			x
2			x			x			x			x			x			x					x			x			x			x			x
3		x				x			x			x	x			x							x			x			x			x			x
4	x					x		x			x				x	x				x			x			x			x			x			x
5	x			x			x			x			x			x				x			x			x			x			x			x
6	x				x			x		x			x			x					x			x			x			x			x			x
7			x			x			x			x			x			x			x			x			x			x			x			x
8	x					x	x			x			x			x					x			x			x			x			x			
9		x				x			x			x	x			x					x			x			x			x			x
60	x					x	x			x			x			x						x			x			x			x			

TABLE I —(*Continued*).

Series	1.												2.				3.				(3*a*).				4.								5.			
Observer	A			B			C			B			C			B			C			B			C			B			C			B			C		
Grading	1	2	X	1	2	X	1	2	X	1	2	X	1	2	X	1	2	X	1	2	X	1	2	X	1	2	X	1	2	X	1	2	X	1	2	X	1	2	X
Sample.																																						
61	x				x		x				x		x			x			x									x			x			x					
2			x			x			x			x			x			x			x								x			x			x			x	
3			x			x			x			x			x			x			x								x			x			x			x	
4	x					x			x			x			x			x			x								x			x			x			x	
5			x			x			x			x			x			x			x								x			x			x			x	
6	x					x	x				x				x			x			x								x			x			x			x	
7	x			x			x			x			x			x			x			x								x	x			x	x				
8	x				x				x	x			x			x	x					x	x							x	x			x	x				
9	x			x					x	x			x			x	x					x	x							x	x			x	x				
70	x					x			x			x	x			x			x											x			x			x			x	
71	x				x		x			x			x				x				x								x			x			x				
2		x				x			x			x	x				x				x								x			x			x			x	
3			x	x					x	x			x				x				x								x			x			x			x	
4	x			x			x					x			x		x				x								x			x			x			x	
5	x					x			x			x			x		x			x								x			x			x			x	
6			x			x			x			x			x		x			x								x			x			x			x	
7			x			x			x			x			x		x			x								x			x			x			x	
8			x			x			x			x			x		x			x								x			x			x			x	
9			x			x			x			x			x		x			x								x			x	x						
80			x			x			x			x			x		x			x								x			x			x			x	
81		x				x		x				x			x	x			x			x						x			x			x			x	
2	x					x			x			x		x			x			x								x			x			x			x	
3	x					x			x			x	x				x			x								x			x			x				
4			x			x			x			x			x		x			x								x			x			x			x	
5	x					x		x				x			x		x			x								x			x			x			x	
6		x				x			x			x			x		x			x								x			x			x			x	
7	x				x		x					x	x				x			x								x	x			x			x			x	
8			x			x			x			x			x		x			x								x			x			x			x	
9			x			x			x			x			x		x			x								x			x			x			x	
90			x			x			x			x			x		x			x								x			x			x			x	

TABLE I —(*Continued*).

Series	1.									2.						3.						(3a).						4.						5.					
Observer	A			B			C			B			C			B			C			B			C			B			C			B			C		
Grading	1	2	X	1	2	X	1	2	X	1	2	X	1	2	X	1	2	X	1	2	X	1	2	X	1	2	X	1	2	X	1	2	X	1	2	X	1	2	X
Sample.																																							
91		x				x			x			x			x			x			x						x			x			x			x		
2	x					x		x		x			x					x	x								x		x			x			x		
3	x					x	x			x			x			x					x						x		x			x			x		
4	x					x	x			x			x					x			x						x		x			x			x		
5	x					x			x			x		x				x			x						x			x			x					
6	x				x				x			x			x			x			x						x			x			x			x		
7		x				x			x			x	x					x			x						x			x			x			x		
8		x				x			x			x			x	x					x						x		x			x			x		
9		x				x			x			x			x			x			x						x		x			x			x		
100			x			x			x			x			x			x			x						x			x			x			x		
101			x			x			x			x			x			x			x					x	x			x			x					
2			x			x			x			x			x			x			x						x			x			x			x		
3	x			x				x		x					x	x					x						x			x			x			x		
4			x			x			x			x			x			x			x						x			x			x			x		
5			x			x			x			x			x			x			x						x			x			x			x		
6		x			x				x			x	x			x					x						x		x			x			x		
7			x			x			x			x			x			x			x						x			x			x			x		
8			x			x			x			x			x			x									x			x			x			x		
9			x			x			x			x			x			x			x						x			x			x			x		
110		x			x				x			x			x	x					x						x		x			x			x		
111			x			x			x	x			x					x			x						x			x			x			x		
12			x			x		x				x			x			x			x						x		x			x			x		
13		x			x		x					x			x			x			x						x			x			x					
14	x			x					x	x			x			x					x						x			x			x			x		
15	x					x			x			x			x			x			x						x			x			x			x		
16		x				x	x			x			x			x					x					x			x			x			x		
117			x			x			x			x			x			x			x						x			x			x			x		
Totals	48	26	43	11	21	85	20	26	71	20	12	85	36	5	76	17	5	95	17	19	81	..	1	36	2	1	5	14	18	85	30	11	76	10	11	96	34	2	81

TABLE 2.

Data and Results, Comparison Tests for Striae in Optical Glass.

Series.	Observer.[1]	No. of pieces first grade.	No. of pieces second grade.	No. of pieces X grade (x).	Usable glass ($117-x$).	Per cent.				
						First grade.	Second grade.	Sum (Usable glass).	X Grade (Strictness).[2]	Average strictness for two observers.
1	A	48	26	43	74	41.02	22.22	63.24	36.76[3]	66.6
	B	11	21	85	32	9.40	17.94	27.34	72.66	
	C	20	26	71	46	17.09	22.22	39.31	60.69	
2	B	20	12	85	32	17.09	10.25	27.34	72.66	68.8
	C	36	5	76	41	30.77	4.27	35.04	64.96	
3	B	17	5	95	22	14.53	4.27	18.80	81.20	75.2
	C	17	19	81	36	14.53	16.24	30.77	69.23	
4	B	14	18	85	32	11.96	15.38	27.34	72.66	68.8
	C	30	11	76	41	24.78	9.40	34.18	64.96	
5	B	10	11	96	21	8.54	9.40	17.94	82.06	75.6
	C	34	2	81	36	29.05	1.70	30.75	69.25	

[1] A. Hageman, Brashear's regular inspector; B. Hinkel, Bureau of Standards regular inspector; C. Dodd.

[2] This number taken as a relative measure of strictness of grading.

[3] To avoid possible misunderstanding due to the grading strictness number of observer A being considerably below the numbers of the other two observers, the point, mentioned in the discussion, should be noted, as to Brashear's relying upon the final test of performance of the finished prisms.

TABLE 3.

Comparison Methods, Bureau of Standards Grading—Summary.

Series.	Method.	Light[1] conditions.	State of samples.	Strictness of grading. Observer. B.	Strictness of grading. Observer. C.	Average.	Date of tests, 1919.
1.....	Brashear	White	Ends polished	72.66	60.69	66.6	July 7
2.....	Tank immersion (B. S.)	Monochr.(?)	Ends polished	72.66	64.96	68.8	July 8, 9
3.....	Short range projection (B. S.)	White	Ends polished	81.20	69.23	75.2	July 10
4.....	S. R. P. + T. I. (B. S.)	White	Ends ground	72.66	64.96	69.2	July 16, 17
5.....	T. I. (B. S.)	Monochr.(?)	Ends ground	82.06	69.25	75.6	July 18, 19

[1] See also description of apparatus.

while the same 6 samples not graded X in the five series by observer B were so graded in all series by observer C. None were graded either firsts or seconds by B in all five series, while C gave first grade to three samples (17, 61, 67), and second grade to none, in all series.

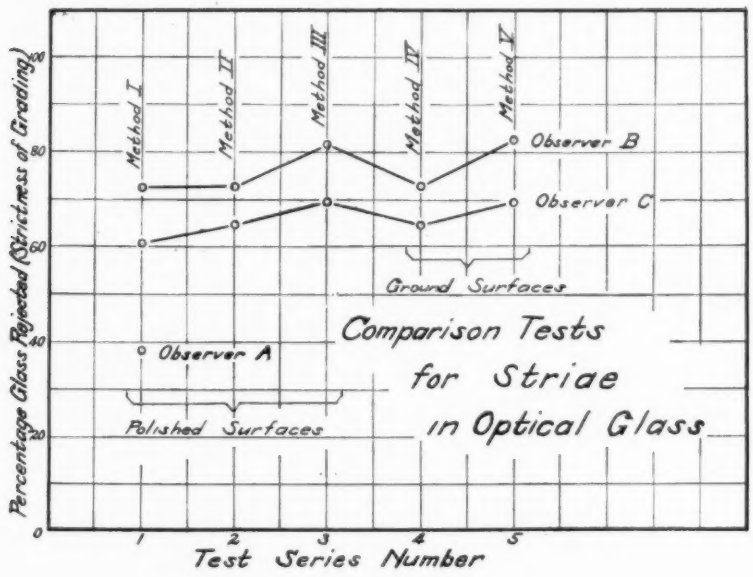

Fig. 3.

The variation (see Fig. 3) from one series to another, of the mean grading strictness number, is the same as that shown by the strictness numbers for each of the individual observers. This parallelism, throughout all the five series, of the two observers' independent judgments as they apply to the set of samples as a whole, tends to build up confidence in the data, for it indicates that a given experienced inspector's grading is consistent.

The fact that observer C's grading strictness numbers throughout the five series of tests are considerably lower than observer B's, is doubtless due principally to a difference in the grading scales of the two individuals. A grading scale is in the last analysis a matter of the individual's judgment, however he may

be called upon to modify that scale to conform to particular requirements. There may possibly enter also in the present gradings by the Bureau inspectors a factor, which is at any rate of minor importance, due to the fact that observer C, while he had had considerable experience in routine testing of glass samples some months previous to the present tests, had not been doing such regular inspection during the interim, and for that reason the faintest striae seen by observer B may have escaped him, owing to his being "out of practice" in detecting the faintest striae. Locating the faintest striae presents the same difficulty as locating a bird in flight when its course has not been previously followed and it is barely visible in the distance. Observer B, on the contrary, had been doing almost daily routine inspection for about two years, up to the time of these tests, and during this period he must have graded tens of thousands of samples. He should thus be expected to show more proficiency in discovering faint striae than observer C. Or a consistent difference in two observers' gradings might be due in part to a difference in vision. This difference in grading does not however affect the conclusions, for it is consistent and thus indicates freedom from erratic judgment on the part of both observers.

Since the ends of the prisms were polished, it was not necessary to use the tank test for Series 2, except for a comparison of the effectiveness of the light conditions in it with the other methods. It did, however, make possible the seeing of striae through the ground sides, impossible in the other two methods where immersion is not used with them. But in these comparative tests the samples were not graded on the basis of striae visible through the sides, but only striae visible through the ends. Thus one sample in particular was noted where striae not visible at all though the ends were plainly visible through the sides. There is nothing to prevent the use, if desired, of a tank with the apparatus of Method I.

During the tests, just before the samples were subjected to end grinding to remove the polished surfaces preliminary to Series 4 and 5, it was learned that the small electric lamp could be run safely at a considerably higher intensity than had been used in Series 3, with correspondingly improved visibility of the striae.

The lamp under these conditions was probably running nearer its rated capacity than with Series 3. (As resistance in series with the lamps four and five 12–16 volt lamps were used in parallel for the two intensities respectively.) This improved visibility of striae with increased intensity of the light means that the percentage, or grading strictness numbers, for Series 3 should in reality be higher than those given. But since the difference would be in favor of the S. R. P. method rather than derogatory to it, the numbers as first obtained in that series with light intensity lower than necessary for safety to the lamp, are retained and presented in the table. The higher intensity was used for Series 4.

To make sure of this increased visibility with the higher light intensity the samples graded in Series 3 as "usable," were re-graded under the same conditions, but with the increased intensity, with results of observer B given in Series (3*a*). Eight of these samples selected at random were then regarded by observer C, with results shown in the same series.

Another factor, besides lower intensity tending to keep the values of Series 3 down, and also those of Series 4, was the real image of the filament formed by the bulb and located about 2 mm. to one side of the filament itself. This real image had far less intensity than the filament, but nevertheless it formed a separate source with intensity sufficient to give, with a slit (pin-hole camera principle), a distinct line of light parallel to that due to the filament itself and some distance from it. Thus there was present with the S. R. P. method as used in these series, the defect of a source extended unduly on account of this real image not coinciding with the filament. This defect is doubtless removable in such lamps, by better centering of the filament in the bulb.

In Series 1, the fact that observer A (Brashear's inspector), is so decidedly below observers B and C in strictness of grading, does not mean that he failed to see the striae. Such an outcome is to be expected since Brashear's test the samples later as to optical performance of the finished pieces, and have found that samples which look poor in the striae test may give good performance in the finished pieces, while samples that appear to be even free from striae (viewed lengthwise) may give unsatisfactory

performance. Upon this fact both McDowell and Hageman of Brashear's laid emphasis. The Bureau of Standards grading, as it has been done at the glass factory in Pittsburgh, has been entirely on the basis of visible striae.

With reference to Series 2, the strictness number of observer B here is the same as his number in Series 1. But there is a marked increase in C's number, and the conclusion is that Method II is at least as effective as Method I.

The general increase of the grading strictness numbers over the first three series is significant. If all experimental conditions for each of the three series had by chance been equal, some increase from one series to the next might have been expected, on the ground that the observer becomes, with each successive grading, better acquainted with the individual samples. But in the present case this explanation rests on only a very slight foundation. The number of samples, 117 in all, is too large for any considerable number of them to be definitely recalled, particularly when the total number of different tests is limited to only five, as in the present work. Furthermore, it is probable that the samples most likely to be recalled are the ones with the heavier striae, samples that were rejected in all the series of gradings. Again, the order in which the samples were placed before the observer was independent in the different tests, and the observer was unaware of the number of any particular sample before him. This explanation is therefore rejected.

The alternative then is that the reason for the progressively increasing strictness of grading for the three successive tests with polished surfaces, lies in the experimental conditions. If this explanation is accepted the conclusion is that the tank immersion test as used for routine testing by the Bureau of Standards, is fully as favorable to strict gradings as the Brashear apparatus in its present manner of operation, and that the S. R. P. method with polished surfaces is at least the equal (see Series 5 and later discussion) of the B. S. modified tank immersion method.

It was not anticipated that Method II would prove itself superior, or even equal, to Method I in effectiveness. In fact it had been rather regarded as somewhat inferior, because of the

question, already mentioned, of lack of monochromatism, due both to the use of uncorrected lenses and to a segment of the spectrum of some length entering the pupil of the eye (see description of apparatus).

It might conceivably be urged that the grading by the Bureau's inspectors, but with the apparatus of Method I, is not so strict as it should be due to lack of familiarity with that apparatus. But Method I belongs to the direct view type, the same as the tank immersion method of the Bureau, and although the light in the former is slightly converging as it traverses the sample while it is slightly diverging in the latter method, the visibility conditions would not appear to be different in the two cases.

Comparing Series 2 and 5—since in Series 5 with ground surfaces the match between glass and liquid may be regarded as perfect, as far as absence of obscuration of the striae by the surface markings was concerned, the higher strictness of the grading for this series as compared with Series 2, is noteworthy. As far as known, the conditions for both series were the same with the sole exception of the necessity for a match of indices between glass and liquid to render the ground surfaces invisible in Series 5. If the match was not perfect then the grading strictness for Series 5 should be lower than that for Series 2, whereas the opposite is the case. If the match was practically perfect for the purpose, as it doubtless was, the two series should be equal as to grading.

A possible explanation to be offered for the difference is one previously suggested for the first three series, *viz.*, a progressively increasing strictness of judgment from series to series in the order in which the tests were actually run (which is the order indicated by the series numbers), an increasing strictness due possibly to constantly improving acquaintance with the samples, or conceivably to some other reason of a psychological nature. But, as already pointed out, memory of the appearance of the striae patterns of individual samples would be expected to be confined almost entirely to those samples showing heavier striae, which in all tests would be rejected anyway; the finer striae were often too numerous to give the individual sample a characteristic striae pattern easily to be recognized. That the increase, in the case of these two series, has a definite cause with an independent

effect on both observers is shown in that each of the observers gives an increase independently.

It is not improbable that some experimental condition, such as adjustment of the lamp filament image on the pinhole, or intensity of the light due to differing voltage on the power circuit used, was more favorable to visibility of the striae in Series 5 than in Series 2. For the factor of light intensity appears to be important to the visibility, over a certain range of intensities at any rate. However, since the illumination system regularly used in the tank immersion test of the Bureau was employed in the present work only for these two series, the cause of this difference in the values, if it was to be found in this system, affects these two series alone. Allowance has been made for this difference, in the manner of statement of the conclusions. For purposes of a strict comparison of the B. S. tank immersion method with the others in the present work, the higher values of Series 5 should be retained.

In any event, with further reference to the difference between the two Series 2 and 5, the comparison of the short range projection method with the others is favorable to its adoption for regular use in the inspection of optical glass for striae, even with white light, which makes possible the elimination of all prisms and lenses from the testing apparatus (see concl. 9).

Brashear's tested the samples in the rectangular prism form, for striae, strain, coma, and other defects such as seed (bubbles). As a matter of fact it does not appear to be necessary to cut glass down from the original molded blank in order to test for strain, as proper annealing should have eliminated this defect from the blank, which could have been tested for strain in the blank form. Further, inspection for striae could have preceded the annealing. Coma as detected by Brashear's in part of the rectangular prism samples is due to the presence of striae, which affect the light rays in the same manner as a lens off axis. According to Brashear's coma will sometimes be found when no striae are visible in the rectangular prism samples as tested endwise at that plant. In such cases, however, an immersion test through the ground side surfaces would doubtless reveal striae.

Because the plane-parallel ends only of the rectangular prisms

were polished, Brashear's did not test them through the sides, with their striae apparatus. Striae inspection, or tests of other kinds, through the ends of the samples in the rectangular prism shape would probably be entirely reliable for judging the final performance of the finished piece if the rays of light passed through the glass parallel to the long axis, as they do, roughly at least when the striae test is made (the light converges somewhat in the Brashear apparatus, Fig. 1*a*). But in the finished rotating prism form the rays do not travel roughly parallel to this axis. Consequently, where the samples have been tested in the rectangular prism shape through the ends only, the performance of the finished rotating prism is the only final criterion of the optical value of the piece, as far as striae affects it, for the purposes desired.

Brashear's have doubtless been willing to permit the limitations of end view only of the samples in the striae test, because of the fact that a sample which shows itself nearly or entirely free from striae (when viewed endwise) may give poor performance in the finished piece, while a sample showing striae to an apparently serious extent may ultimately give good performance. This fact must depend upon the nature, *i. e.*, shape, size, and orientation relative to the rectangular prism axis, of the striae.

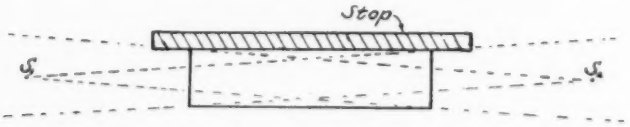

FIG. 4.—Sample in place in apparatus of Method I. (Plan.) (Angles are exaggerated.)

S_1, and S_2,—relative positions of source in direct and reverse positions of the sample, respectively.

While this final test is adequate the method is wasteful where prisms in the finished form have to be rejected, on account of unsatisfactory performance, after the expense of working the glass. The original molded samples should be and can be thoroughly tested for both strain and striae before any trimming is done, so that there will be no necessity of rejecting any pieces in the finished form. Such thorough testing of the original

molded blanks should have been done before the glass reached the lens grinders.

The experience of the Bureau has been that if glass is molded by a suitable method, the molded surfaces will be in such a state of comparative smoothness that the samples can be readily tested for striae by the immersion method without being ground or trimmed at all.

While it is true, as Brashear's experience has proven, that samples may show striae quite decidedly and still give good performance in the finished pieces, it is more economical to reject at the outset all glass showing striae to any serious extent. Furthermore, the tests made of the molded blanks at the outset should be through the sides as well as the ends.

Since the light in the Brashear apparatus is converging while the long axis of the sample has a fixed position, not all the sample is visible, for the parts near the sides are inaccessible to the rays, as Fig. 4 shows, even though the sample is turned end for end. This slight disadvantage can be easily remedied by permitting the prism freedom of movement on its supporting platform, so that by a small amount of horizontal rotation the light can be let through the sample parallel to one side at a time.

This circumstance in Method I of the sample being in a fixed position relative to its long axis may have been responsible for some lowering of the grading strictness values for this method below what they might otherwise be. But the conclusions will not be affected, since they refer to Methods I and II as these had been in regular use. But it is to be noted that the grading values for the S. R. P. method (Series 3 and 4) are doubtless lower than they should be owing to the real image of the filament which has been mentioned. It has already been mentioned that a higher light intensity in Series 3 would have raised the values.

Given a light source of good concentration, any extension of it will lower the visibility of the striae. As stated in the introduction to the paper since a line source is concentrated in one direction, that transverse to its own length, and has maximum extension in the direction perpendicular to this, the visibility of striae with such a source is non-uniform, being a maximum relative to the direction in which the light is most concentrated.

Method I, while using the principle of a really concentrated, or point, source, still gives the non-uniform visibility similar to that due to a line source, on account of the straight-edged, opaque screen at the position of the observer's eye. Thus it is Brashear's custom, when viewing the rectangular prism sample endwise, as is necessary where only the ends are polished, to turn it, at least from the position where side "*a*" (see Fig. 5) is in the downward direction, to that where side "*b*" is down, a rotation of 90°. If necessary for the grading, the sample is placed successively in the eight different possible positions, where sides *a*, *b*, *c*, and *d* are down and the sample is turned end for end. This procedure, of turning the sample from the position of side "*a*" down to side "*b*" down is necessary to compensate for the lowered visibility, with a given position of the sample, of striae components that run perpendicularly to the direction of the screen's edge. In using Method I the Bureau's inspectors noted this marked dependence of position of sample on the visibility and appearance of striae.

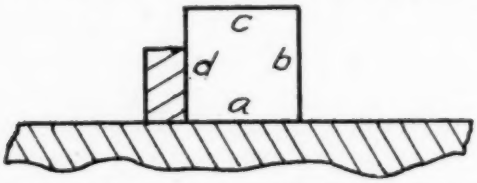

FIG. 5.—Sample in apparatus of Method I. (End view.)

The possible point might be made that since the variation in the percentages do not involve large numbers of individual samples, such variation is easily subject to over-emphasis. But special attention was paid to making all the inspection and gradings in these series with care and deliberateness. Trustworthiness of the results is moreover indicated by the parallelism of the two observers' judgments throughout the tests.

It might be contended that a greater strictness in the grading with a method possessing some novelty is to be expected on psychological grounds, *viz.*, anxiety to see the new method succeed, so that the observer's judgment is affected in a way to enable the method to show up well in comparative tests. But a special effort was made throughout the tests to guard against anything

of this sort, and it is believed the effort has been effective, if the tendency mentioned was present at all in any serious degree.

Advantages of the S. R. P. Method.

There are certain advantages of the S. R. P. method for detecting striae, some of them peculiar to it, which are obvious.

1. The distance from the observer's eye to the translucent screen may always be that of most distinct vision (about 25 cm.), so that the striae shadow patterns have maximum clearness as far as the eye itself contributes to it.

2. Since the striae patterns are all in one plane there is no time lost adapting the eye focus to different depths in the sample, with ensuing fatigue of the observer due to this cause.

3. Striae can be readily located in the glass sample incidental to the turning of the sample during inspection. Such location of striae is necessary where samples are to be trimmed by sawing, by splitting or chipping with the hammer, or otherwise. The relative movements of the shadow figures on the screen determine the positions in the sample of the striae or other defects causing them. This ease of location has also been clearly shown where the rectangular slabs of optical glass as molded by the Bureau with the punty[1] have been tested through the edges by the S. R. P. method. A simple rotation of the slab in its own plane suffices to locate quickly the striae in it.

4. By the use of divergent rays the striae shadow figures are given some magnification on the screen, and this is an advantage up to a certain limit of magnification, which limit is easily avoided with the S. R. P. method. This objection of too high magnification and thus a serious lowering of the visibility is likely to be present where the projection is not of the short range type. (The relative effectiveness of the short range projection method with parallel or convergent light, as compared with divergent, remains to be demonstrated.)

5. The S. R. P. apparatus is compact, and manipulation of the glass samples by the observer can be done with the greatest ease.

[1] The punty method was introduced into the government's glass factory by Capt. Harry Fry.

6. A darkened room is unnecessary for the inspection, as a small hood of stereoscope type will keep extraneous light from the observer's eyes. There is no difficulty preventing outside rays from entering the sample, for with polished samples that do not require immersion a small chamber may be adapted to shield them during the test. This chamber may be curtained to permit entrance and withdrawal of the test pieces. With samples requiring immersion the cover of the tank used, attached to the carriage supporting the piece during the test, affords such protection.

Conclusions.

1. The consistency of a given observer's grading, with a set of samples of sufficiently large number to avoid serious duplications of judgment by memory, is indicated in the numerical results by the very similar variations of the two observers' judgments, as expressed in the summary table by percentages (see diagram also). This conclusion is borne out by the additional fact that the ratio of the number of the same samples in the set graded X by observer B in all the five series, to the similar number graded X by observer C, is in agreement with the roughly constant difference in strictness of grading by these two observers throughout the work.

2. Comparing Series 1 and 2—the illumination system in the tank immersion method as regularly used by the Bureau of Standards makes possible a grading fully as strict as with the Brashear apparatus.

3. Comparing Series 1, 2 and 3—the short range projection method, when the samples have polished surfaces, is at least equal (cf. Series 5, also discussion of Series 2 and 5) to either of the other two methods as they have been regularly used.

4. Comparing Series 1, 2 and 4—the short range projection method with samples having ground ends, and with tank immersion but white light, in spite of the poor index match between glass and liquid due to the white light, compares favorably with the Brashear method and the Bureau of Standards tank immersion method, as these have been regularly used.

5. Comparing Series 3 and 4—the short range projection method with samples having ground ends and with tank im-

mersion (B. S.) but increased light intensity (see discussion) is equal in effectiveness to the S. R. P. method alone with samples having polished surfaces but with lower light intensity, in spite of the imperfect index match due to the white light. Striae can be detected even though their images on the translucent screen are superposed on the ground glass shadow patterns.

6. Comparing Series 3 and 5—the inference is that since the short range projection method with samples having polished surfaces but with white light, is about equal in effectiveness to the tank immersion method with samples having ground surfaces and with approximately monochromatic light, the S. R. P. method with monochromatic light of suitable intensity will be found superior, due to absence of dispersion by the striae under such light conditions.

7. Comparing Series 2 and 4—the Bureau of Standards tank immersion method with samples having polished surfaces, and the short range projection method with samples having ground surfaces but with tank immersion and white light, are of about (see discussion of Series 2 and 5) the same effectiveness. The S. R. P. method with ground surfaces and monochromatic light, giving a perfect index match, should therefore be expected to prove the equal or even the superior (see concl. 8), if only on account of the advantages peculiar to short range projection of the tank immersion method as used at present by the Bureau. (Conclusions as drawn from the two series of tests (2 and 4) will be modified in favor of the short range projection method where the inspection is performed, not with ground surfaces, but either with fractured surfaces, as found in glass fresh from the broken pot or recently broken with the hammer, or samples in the form of molded slabs as they are produced at the Bureau of Standards with the punty, which gives fairly smooth molded surfaces. Such fractured or smoothly molded surfaces, as contrasted with rough ground surfaces, have in general a minimum number of markings.)

8. Reference to the diagram shows that the short range projection method with polished samples (Series 3) stands on an equal footing with the B. S. tank immersion method (Series 5) where that method appears to have had better conditions of

visibility (see discussion of Series 2 and 5). Moreover, the results for these two series (3 and 5) give the highest values for strictness of grading in the entire series of comparative tests. It should therefore be noted that in Series 3 the visibility afforded by the S. R. P. method was not at its maximum, owing to the lower intensity of the lamp source as used during the grading in this series. Therefore, the S. R. P. method in its simplest experimental form and with samples having polished surfaces is the superior of any of the other four methods as employed in these comparative tests.

9. In view of the results as a whole, although they were obtained with a lamp that has not reached the limit of practicable concentration of filament, and in which the real image of the filament due to the bulb did not coincide with the filament itself, the comparison of the short range projection method with the others is favorable to its adoption, for regular use in the inspection of optical glass for striae, even with ground surfaces and white light, which makes possible the elimination of all prisms and lenses from the testing apparatus.

In conclusion, the Bureau is indebted to Brashear's for permission to make one series of the comparison tests at that plant, particularly to Mr. J. B. McDowell, superintendent, and Mr. Hageman, both of Brashear's, and to Colonel Scoville of the Department of Ordnance, Pittsburgh Branch, for their interest and assistance. For needed apparatus loaned for use in connection with this work, thanks are extended to Dr. Frank Schlesinger of Allegheny Observatory, and to Professor Harry S. Hower of the Department of Physics, Carnegie Institute of Technology. The writer wishes to express his appreciation of the coöperation of the Bureau men, and of the assistance, throughout the tests, of Mr. Walter J. Hinkel.

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NOTE ON THE LATENT HEAT OF FUSION OF CRISTOBALITE.

By Edward W. Washburn.

The only means at our disposal for estimating the heat of fusion of quartz is through the application of the law of freezing point lowering. In a previous paper[1] the writer employed the freezing point law of the "ideal solution" in order to estimate the latent heats of fusion of lime and magnesia, the assumption being made that these two substances were so much alike that their solutions might be assumed to obey the laws of ideal solutions.

In the present instance this assumption is inadmissible in any of the known phase rule diagrams of binary systems containing SiO_2 and in applying the law we are therefore restricted to "dilute solutions" that is, to solutions in which the mole fraction of silica is large. For this case the same law is applicable but it may be thrown into the more convenient form

$$L_{F_0} = \frac{RT_{F_0}^2}{\Delta t_F} x_1. \qquad (1)$$

In order to apply this equation to the present case, we must therefore make use of a point in the cristobalite liquidus as near as possible to the melting point of cristobalite. The nearest point of this kind which has been determined at all accurately is the point at 1610° C corresponding to the eutectic between cristobalite and sillimanite. According to Rankin and Wright[2] the composition of the melt at this point is 87 per cent SiO_2 and 13 per cent Al_2O_3. This composition gives 0.0808 as the mole fraction of alumina in the melt, if we assume that none of it is combined with the silica. If on the other hand, as is more probably the case, we assume that practically all of the alumina is present in the solution in the form of sillimanite, the above composition gives 0.0882 as the mole fraction of the sillimanite.

[1] *Trans. Am. Ceram. Soc.*, **19**, 195 (1917).

[2] *Amer. J. Sci.*, **39**, 9 (1915).

In order to calculate the molal heat of the fusion, L_{F_0}, of cristobalite we have only to substitute the appropriate values in equation (1) above, where R (= 2 cal.) is the gas constant, T_{F_0} (= 1710° + 273°) is the absolute melting point of cristobalite, Δt_F (= 100°) is the freezing point lowering (*i. e.*, 1710–1610°) and x_1 is the mole fraction of the solute,[1] in this case Al_2O_3 or Al_2SiO_5.

If we assume that the solute is Al_2SiO_5 with the mole fraction 0.0882 we find L_{F_0} = 6950 cal. If we make the less probable assumption that the solute is Al_2O_3 with the mole fraction 0.0808, we find L_{F_0} = 6360. The average of these is 6650 but since the greater weight should be given to the former value we shall write:

$$L_{F_0} = 6800 \text{ cal. per mole}$$

or

$$l_{F_0} = 110 \text{ cal. per gram.}$$

In the above calculations it is assumed that the solute exists in the solution in the form of molecules having molecular weights corresponding to the formulas written. If association occurs the above value for the heat of fusion is too large.

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[1] Cf. p. 172, eq. 48, of Washburn's "Principles of Physical Chemistry," McGraw-Hill Book Company, New York, 1915.

CERAMIC ABSTRACTS.

General.

The efficient arrangement of a clayworks. *Brit. Clayworker*, **28,** 182 (1919). —In most plants the output is increased with increased sales and reduced with reduced sales. A better way is to have a standard output with provision made for increased output in the future based upon the past growth. Every plant should have an entering- and leaving-end and the material should pass from one operation to another in as nearly a straight line as possible. The individual output of each machine should be established with extreme care to determine how it will fit up with the other parts of the arrangement. In designing a plant a plan of the works is made to scale, $^3/_8$"–$^1/_2$" = 1 foot, showing all features of the scheme, and arrangement. Then for each machine an approximate shape to clearance dimensions is cut out in cardboard to the same scale as the plan, showing the position of the drive, the position of the operator, and the extreme travel of the working parts. At the same time cardboard cutouts are made of transfer trucks, bins, work benches, etc. This is done for every piece appearing on the tabulated sheet. The cutouts are now combined to the best advantage so that all may be busy all the time. Each piece should be considered with respect to the other and each should be moved about until the best arrangement has been found. All unnecessary travelling should be avoided and the gradients and differences in level between machines, etc., should be carefully studied. Great care should be taken in handling the finished brick as they are more costly than clay and cheaper transportation may be used for clay as it is not damaged by transport. When the cardboard cutouts representing the buildings and machinery have been arranged they should be tested by the handling factor (weight × distance) to reduce these as much as possible.

H. G. SCHURECHT.

Manufacture of roofing tile. *Brit. Clayworker*, **28,** 179 (1919).—Plain roofing tiles may be made most satisfactorily by "running" them out of a brick machine fitted with a special mouthpiece so as to form a column of clay of the desired width and thickness, which, when cut into pieces the length of the tiles, will provide a clot which is later pressed, or the nibs may be formed by the deft finger of an attendant. Some difficulties and methods of overcoming them are described as follows: (*a*) In one case the clay was "short" and could not be handled without breaking. The clay occurred in stratas of different kinds, some being too high in fine silt. The clays high in fine silt often appear as plastic as those high in clay substance so the "feel" test

cannot always be relied upon. A method of testing for silt in a clay is to stir with water and allow the same to settle. Decant liquid and repeat several times. It will be found that clays high in silt will leave a comparatively large residue in the beaker. Using a clay low in silt overcomes this difficulty. (*b*) Jagged corners were produced on the column of clay. When more water was fed to the corners in lubricating the mouth piece and the shape of the mouth piece was altered this trouble disappeared if highly plastic clays were being used but it was not entirely overcome where silty clays were used. (*c*) The column of clay was curved—due to the clay passing out more rapidly from one side of the mouth piece than the other. This was prevented by enlarging the hinder part of the mouth piece on the inner edge of the curve so as to allow the clay to enter the mouth piece more freely. (*d*) The tile cracked in drying —due to insufficient lubrication of the clay in the mouth piece. This was due to shutting off the water in the lubricator of the mouth piece and the trouble was overcome by keeping the water turned on at all times. (*e*) The top of the tiles were slightly rounded—due to expansion of the tile as they came through the mouth piece. By altering the shape of the die this was overcome. (*f*) Laminations caused by the screw of the auger being too near to the mouth piece were overcome by inserting a barrel between the machine and mouth piece. The mouth piece had a scaled interior composed of a series of overlapping sheets of copper or zinc, so arranged that the water escaped through the overlapping portions. H. G. SCHURECHT.

Cements for spark-plug electrodes. H. F. STALEY. *Report No. 53*, of The National Advisory Committee for Aeronautics, 33–34 (1919).—Considerable trouble has been caused in airplane engine work through the breaking of the central electrode of spark plugs. An investigation of this problem by the Bureau of Standards shows that in many cases the cement used to hold the nickel electrode wire in the porcelain is of such a nature that it rapidly eats away the wire through oxidization, when exposed to the high temperatures of the engine cylinder. A cement composed of silicate of soda and raw kaolin has been found to give the least trouble in this respect. In cases where the cement holds the wire firmly in the porcelain the latter often cracks when subjected to heat—due to the difference of the coefficients in expansion of the wire and the porcelain. The breaking of the porcelain does not seem to be due to leaky plugs as has often been supposed to be the case. On account of the difficulties attending the use of any form of cement between the porcelain and central electrode, the elimination of the cement and the use of a mechanical seal at the top of the porcelain is greatly to be desired. In such a plug only a porcelain strong enough to safely withstand the resulting stresses should be used. The porcelain recently developed by the Bureau of Standards is believed to meet these requirements. H. G. SCHURECHT.

Method of measuring resistance of insulators at high temperatures. F. B. SILSBEE AND R. K. HONAMAN. *Report No. 53*, of The National Advisory

Committee for Aeronautics, 1–13 (1919).—The temperature of the body insulators of a spark plug within a metal shell seldom exceeds 250° C in water-cooled engines. The tip of the inner end, however, may reach temperatures as high as 900°–1000° C. The electrical resistance was therefore studied between 200°–900° C. In starting an engine 6000 volts are necessary but after this only a comparatively low voltage (800) is necessary. The spark lasts about a few thousandths of a second and the interval between the sparks is about 0.1 second so the average voltage is about 150. Most of the work was with cup-shaped specimens similar to the standard test piece No. 1 adopted by the A. S. T. M., except that the side walls were uniform in thickness. The advantages of this type of specimen are as follows: (1) The conduction takes place through the bottom of the cup which has definite and easily measured dimensions; (2) the large area and small thickness of the bottom insure a relatively large current even with material of high resistivity; (3) the path over the rim of the cup for any surface leakage is relatively long; (4) a satisfactory constant can be made between the specimen and the electrodes by immersing the bottom of the cup in a conducting fluid (in these experiments, melted solder) and by inserting some of this fluid inside the cup to form the upper electrode. In cases where cup specimens were not available, measurements were made on assembled spark plugs, and also on spark plug insulators, and on short pieces of tubing. In these cases the conduction took place between a central electrode and either the shell of the spark plug or a band of platinum deposited around the shell of the spark plug. The measurements with this type of specimen definitely indicated the resistance of the specimen, but owing to the uncertainty as to area of contact and the location of the lines of current flow, it was difficult from such data to compute with accuracy the true resistivity of the material. The resistivity was obtained by multiplying the observed resistance by a factor K, which varied with the shape and dimensions of the specimens. For the cup-shaped specimens $K = \frac{\pi d^2}{4 l}$, where d is the diameter of the bottom and l the thickness of the cup. For tubular specimens $K = \frac{2 \pi l}{2.30 \log_{10} \frac{R_2}{R_1}}$, where l equals the length of the external conducting band measured parallel to the length of the specimen, and R_2 and R_1 are, respectively, the external and internal radii of the insulator. The most satisfactory method for the rapid comparison of different types of insulating materials is by the use of the volt-ammeter, using alternating current. Under these conditions the observed resistance is substantially independent of the frequency of the voltage and the time of application and the convenient values of 60 cycles and 500 volts were adopted for the work. A bridge method using direct current would be objectionable because of the variable amount of polarization which would occur. Some typical results are as follows:

Material.	Te Value. °C.
Fused silica	890
Best porcelain	790
Mica plug	720
Av. of 3 aviation plugs	650
Av. automobile plugs	490

H. G. Schurecht.

Some new appliances in potting. A. S. W. Odelberg. *Pottery Gaz.*, **509,** 1214–1218 (1919).—An electrical conveyor has been installed in the Gustafsberg Pottery, Sweden, for conveying ware from the bisque ovens to the ware-house, from the glost ovens to the ware-house and for transporting from the glost ware-house through the various other ware-houses to the packing shed. This work is now done with 50 per cent less manual labor, with a saving of two hours' time, and with an appreciable reduction of broken ware. For making oval dishes in a jolly, a new method is described in which the jolly is perfectly rigid, all movements being in the jigger head, thus overcoming the disadvantages of the jolly heretofore employed which proved very tiresome to the operator. The grooving of insulators is now accomplished by a felt wheel acting like a circular saw and operated at about 4000 r. p. m. The groove is made in a few seconds by this method. The formation of cup and mug handles in steel dies, heated by electricity, was referred to. Until 1914 platinum wire was used as the heating element, but since then nichrome wire has been substituted and found to last longer and the cost is only a small fraction of that of platinum. The electrical method of handle-making is much quicker and cheaper than the old method of pressing in plaster molds. In the firing of boilers and ovens the "Mono" apparatus, which records the carbon dioxide in the gases as they leave the furnace, effecting economy in fuel and preventing smoking in kilns, is used. A three-color printing machine in which the paper passes through three rollers of exactly the same diameter is described. It is found best to apply yellow with the first roller, pink with the second and blue with the third, as blue is not seriously damaged by a mixture of yellow and pink. H. G. Schurecht.

Efficiency in wall and floor tile production. *Brick Clay Record,* No. 11, 961–964 (1919).—The plant of the Robertson Art Tile Co., Morrisville, Pa., is described. Saggers are made by a hydraulic press and are very satisfactory. The kilns are loaded with portable loading machines of the Brown type. The company has devised its own sand-screening machine which consists of a revolving drum which leads to a cylinder formed of wire, with spacing between the wires sufficient to allow single floor tile to drop through, whereas the tile which stick together work their way to the end of the cylinder. A battery of presses operated by hydraulic power is used for making the tile. H. G. Schurecht.

Geological.

Magnesite in West Australia. F. R. FELDTMANN. *The Mining Magazine*, **21**, No. 4, pp. 240–242 (October, 1919).—The magnesite deposits are located near Bulong, about 20 miles east of Kalgoorlie, and on the west side of Lake Yindarlgooda. The district is made up of a complex of highly basic rocks, the major portion of which consists of serpentine with which the magnesite invariably is associated. A few small areas of gabbro or amphibolized gabbro and sev ral large porphyritic dykes make up the minor part of this complex of basic greenstones. In and near the magnesite area a few small dykes are found. East of this greenstone mass is a belt of rocks of plastic origin, known as pebble breccia. Still further to the east is a second area of greenstones less basic than the rocks of the magnesite area.

The largest magnesite-bearing serpentine area is located about $2^1/_4$ miles due east of Bulong and covers about 350 acres, the southern portion of this area being much covered with surface deposits. North of this main mass are several smaller occurrences of the magnesite-bearing serpentine. The largest of these covers about 90 acres. It is possible that other areas may occur further to the north near Mt. Taurus.

In the pebble breccias and near the boundary of the serpentine, small lenses of magnesite have been found. According to the author the magnesite in these patches has been dissolved out of the serpentine by surface waters and re-deposited in the plastic materials.

The magnesite occurs mainly in the serpentine in the form of short veins which are irregular both as to strike and dip. Most of these veins are only a few inches wide and many of them are threadlike. Where the serpentine is greatly decomposed the veins are very numerous and may be easily quarried. In a few places the magnesite forms a surface deposit which is usually more discolored than the veins. The largest of these surface deposits extends over a large part of an area of about 15 acres.

The proportion of impurities in the magnesite varies considerably as shown by the following analyses:

ANALYSES OF BULONG MAGNESITE.

	1.	2.	3.
Magnesia, MgO	47.36	44.96	44.31
Carbon dioxide, CO_2	51.69	49.33	47.76
Combined water, H_2O+	...	0.08	nil
Moisture, H_2O-	0.15	0.97	1.17
Silica, SiO_2	0.12	1.12	4.99[1]
Alumina, Al_2O_3 Ferric Oxide, Fe_2O_3 Ferrous Oxide, FeO	0.16	0.56	0.42
Lime, CaO	nil	1.06	nil
Sodium chloride, NaCl	0.53	1.76	1.39
Potassium Chloride, KCl	0.01	0.09	0.08
Magnesium Chloride, $MgCl_2$	0.08	nil	0.11
Sulphur Trioxide, SO_3	trace	0.13	0.15
Total	100.10	100.06	100.38

[1] The specimen contained small veins lined with chalcedonic silica.

The deposits were not being regularly worked at the time of Feldtmann's visit. In 1917, 73 tons were shipped from Bulong, the export value of the mineral being estimated at slightly less than £4 per ton. E. D. ELSTON.

Geology and mineral deposits of a part of Amherst township, Quebec. M. E. WILSON. *Can. Dept. of Mines, Geol. Survey,* Memoir 113, No. 96, Geological Series, 1919.—Extensive deposits of kaolin occur in the St. Remi district which is in the southern part of Amherst township, Labelle county, Quebec. The district is at the western end of the Huberdeau branch of the Canadian Northern railway and is about 30 miles north of the Ottawa river and almost equidistant from Montreal and Ottawa.

Kaolin has been discovered in two localities, the principle occurrences being in a zone about 1000 feet wide in Grenville quartzite. This deposit extends north-northwest from lot 8 to lot 2, range VI, south, and the kaolin occurs in a much shattered zone, as fine disseminations between the quartz grains, in veins following the planes of fracturing and also in more extensive deposits which in some instances attain a width of 100 feet and a length of several hundred feet. Due to the thick covering of glacial drift the whole extent of the deposit has not been ascertained. Information obtained from trenches, test pits and stripping, however, indicates that the zone is continuous for approximately 7000 feet. The most extensive deposit of kaolin in this shattered zone occurs in lots 5 and 6. Here as shown by stripping, test pits and bore holes, the lead of kaolin is almost continuous for 1400 feet, its width varying from a few feet up to 400 feet, and at one point having a thickness of 150 feet. The kaolin content in masses of kaolin is generally not less than 35 per cent even though the kaolin contains quartzite either as disseminated grains or in fragments. The kaolin leads in the shattered zone are numerous and range from a fraction of an inch up to 65 feet in width.

Farther south, on lot 8, range IV, and near Pike Creek another kaolin deposit occurs. Although no connection has as yet been found it is possible that the deposit may be another outcrop on the same zone as that described above.

Of importance is the fact that the kaolin deposits are associated with a zone of faulting and shattering in the Grenville quartzite. Whether a series of small faults or a single greater fault has brought about the deformation is not clearly discernible. Local evidence would indicate that considerable movement has taken place. Again it is important to note that wherever kaolin is found the quartzite shows much jointing. In addition the quartzite throughout almost the whole of the fracture zone has been much broken and crushed.

According to Wilson, the evidence seems to show that not only is the kaolin due to deposition in openings caused by deformation of the quartzite, but that large masses of kaolin have been formed by replacement of the quartzite. Whether the kaolin owes its origin to superficial weathering and downward percolating waters or to thermal ascending waters has not been determined by the author, since each method seems to be borne out in part by certain lines of evidence.

The kaolin deposits in the northern part of the fracture zone are composed almost entirely of white to cream-white kaolin and quartz while to the south the greater part consists of varying shades of red, brown or yellow due to disseminated hydrous iron oxide. Whether this color persists with depth is unknown. Uncommon impurities consist of fine flakes of muscovite, aggregates of tourmaline and disseminated flakes and aggregates of graphite. The paucity of impurities in the white to cream-white kaolin is shown in the following analyses of the washed product.

Analyses of kaolin from Amherst township:

ANALYSES OF KAOLIN FROM AMHERST TOWNSHIP.

	1.	2.
Silica	46.13	44.43
Alumina	39.45	40.48
Ferric iron / Ferrous iron	0.72	0.04
Lime	none	0.24
Magnesia	none	0.36
Potash	0.20	....
Soda	0.09	....
TiO_2	....	....
Loss on ignition	13.81	14.46
Moisture	....	....
Total	100.40	100.01

According to Wilson, an analysis made by A. G. Spencer shows the composition of the discolored kaolin to be as follows:

	Per cent.
Silica	54.24
Alumina	34.24
Iron oxide	2.04
Lime	2.54
Magnesia	0.46
Loss on ignition	5.87

The materials which occur in the fracture zone are white kaolin, discolored kaolin, kaolinic quartzite, kaolinized granite (cornish stone), and kaolinized garnet gneiss. Owing to the incomplete state of development work any attempt at estimating reserves of these materials is attended with difficulty. Statements of prospective possibilities show the following estimates subject to conditions considered in detail in the paper.

White kaolin—approximately 75,000 tons for every 50 feet of depth; *discolored kaolin*, 250,000 tons; *kaolinic quartzite*, 300,000 tons to 900,000 tons; *cornish stone*, extent unknown; *kaolinized garnet gneiss*, unknown.

Tests made by J. Keele of the Mines Branch are cited and mention is made of the uses of the various kinds of material, as follows:

Kaolin—For the body and glazing of chinaware, porcelain, wall and floor tile, electrical insulators, enamelware, stoneware, etc., filler in manufacture of papers, cotton, and other textiles; as a constituent of certain plasters, paints and coloring agents; as face powder, polishing powder, and in medicinal preparations.

White kaolin and quartzite—Can be mixed with the Pleistocene marine clay of the district to make fire-brick.

Discolored kaolin—Can be used as a fire-clay.

Kaolinic wall rock—For manufacture of ganister type of silica brick, and when freed from kaolin content is suitable for use in manufacture of lime-bonded silica brick, glass, carborundum, and as a steel foundry sand.

Kaolinized garnet gneiss—Possibly as a fire-clay.

Brief notes on the equipment and mining methods and on the production of china clay are also included. E. D. ELSTON.

Preliminary report on the economic geology of Hazelton district, British Columbia. J. J. O'NEILL. *Can. Dept. of Mines, Geol. Survey,* Memoir **110,** No. 89, Geological Series, 36–37 (1919).—Mention is made of a clay from Smithers along the Bulkley river, and results of tests on this clay are given showing it to be suitable for making common brick provided 20 to 30% sand is mixed with it to reduce shrinkage. The clays of this district are chiefly gumbo or boulder clay and are of no economic importance.

E. D. ELSTON.

Sand and gravel in 1918. R. W. STONE. *U. S. Geological Survey, Mineral Resources of the U. S.,* **1918,** Part II, 13 (1919).—Tabulated statements concerning the production of glass sand and brief notes concerning glass sands are to be found in this report. E. D. ELSTON.

Magnesite in 1918. C. G. YALE AND R. W. STONE. *U. S. Geological Survey, Mineral Resources of the U. S.,* **1918,** Part II, 7 (1919).—The publication contains brief statements concerning the magnesite industry, including statistics of production, general facts concerning domestic and foreign occurrences and production of magnesite. E. D. ELSTON.

The Harricanaw-Turgeon Basin, Northern Quebec. T. L. TANTON. *Can. Dept. of Mines, Geol. Survey,* Memoir **109,** No. 94, Geological Series, 58–59 (1919).—Deposits of clay, some of which are suitable for the manufacture of brick, are briefly described in this publication. E. D. ELSTON.

Surface deposits of southeastern Saskatchewan. J. STANSFIELD. *Can. Dept. of Mines, Geol. Survey,* Summary Report **1918,** Part C, 43C–44C

(1919).—Tests were made by J. Keele upon samples of two shales secured near Fairlight, Saskatchewan. According to Keele the shales might be used for manufacture of building brick or for fire-proofing or hollow building blocks. E. D. ELSTON.

The Mackenzie river basin. C. CAMSELL AND W. MALCOLM. *Can. Dept. Mines, Geol. Survey*, Memoir **108**, No. 92, Geological Series, 100–103 (1919).—Clay deposits on the Athabaska river and its tributaries and clays and shales along the Grand Trunk Pacific railway are briefly treated and several laboratory tests are given. E. D. ELSTON.

Road materials in the vicinity of Regina, Saskatchewan. L. REINECKE. *Can. Dept. of Mines, Geol. Survey*, Memoir **107**, No. 90, Geological Series, 3–4 (1919).—The use of natural burnt clay derived from beds adjacent to burned coal seams is mentioned in connection with road materials. A test proved the material as used alone was unsatisfactory for such a purpose. E. D. ELSTON.

Geology of the disturbed belt of southwestern Alberta. J. S. STEWART. *Can. Dept. of Mines, Geol. Survey*, Memoir **112**, No. 93, Geological Series, 61–62 (1919).—Tests made upon shales show materials are of poor quality which after modification might be used for wire-cut bricks or hollow blocks. E. D. ELSTON.

Refractories.

Preparation of raw materials for the manufacture of glass-house pots. B. J. ALLEN. *Brit. Clayworker*, **28**, 172–176 (1919).—In testing 21 fire clays of Great Britain which did not meet the requirements of a No. 1 refractory, it was found that 17 could be sufficiently purified by deflocculation to meet these requirements as far as alumina is concerned. For example, a low-grade sagger clay was purified by deflocculation and 30 per cent non-plastic material removed. After treatment this clay when fired to 1200° C was vitrified. The use of deflocculated clay is recommended as it permits a higher percentage of grog, decreases the temperature of vitrification, and reduces cracking in burning. Grog of the same composition as the fire clay should be used. High-fired grog produces the best results as it not only becomes better distributed in the body but it was shown that about 20 per cent of the alkalies are volatilized by exposing to high temperatures. Black-cored grog should never be used as it causes blow-holes and pin-holes in the glass. The grog should be ground in dry pans with the rollers raised one inch from the bottom of the pan. The scrapers should be set to throw a good body of material under the rollers, with the object of crushing the material into angular rather than spherical fragments. When a magnet is used to separate the iron, care should be taken to prevent loss of iron particles when a drop in voltage occurs. For mixing clay with grog the dry pan is not very efficient because it reduces the grain-size of the grog. Pugging is also unsatisfactory as it does not permit

thorough mixing. Blunging the body in slip form is considered the most satisfactory as the mixing is more thorough than that secured by pugging and the grain size is not altered. A 4-foot blunger should be operated at a high speed —about 80 r. p. m. The alkaline water should be warm. The clay is added to the water first, the fine grog next and the coarse grog last. Some clays which are inclined to gel may be improved by adding barium carbonate. The use of sulphite cellulose liquor as a substitute for sodium silicate is helpful in some cases.

Casting a covered pot in a plaster mold is difficult. It is not possible to cast thicker than $^{7}/_{8}$–1 inch by this method. A hot, excessively dry mold does not give good results as this condition gives rise to "filling marks" and causes the cast clay to come away from the mold too soon. For this reason the experienced caster always sponges the face of the mold taken from the drying shed. Casting by a vacuum casing placed around the outside of the mold permits the casting of thicker walls. If coarse grog is used the insides of pots cast by this method are often rough and should be finished by hand—care being taken not to tear out the grog. An abnormally thick pot or a quicker cast may be obtained by applying pressure to the slip inside in addition to the vacuum on the outside. For casting covered pots the mold is constructed in four parts, namely, base, two sides and mouth piece. The arrangement permits the base to be cast thicker than the sides. The excess slip is removed by suction rather than by turning the mold upside down. In using a vacuum pump for casting it is necessary that a constant vacuum be maintained. The steam-jet, air ejectors are not desirable, since the vacuum varies with the steam pressure, but the Leblanc rotary ejector and the Minlees-Leblanc air pumps are very efficient. H. G. SCHURECHT.

Refractory materials used in coke-oven construction. W. C. HANCOCK. *Brit. Clayworker*, **28**, 155–158 (1919).—The special qualities required are (1) resistance to high prolonged heating under normal or increased pressure; (2) resistance to mechanical abrasion; (3) resistance to sudden changes of temperature; (4) impermeability to gases; and (5) resistance to chemical attack, especially by sodium chloride at high temperatures. Fire-clay brick are used in England because the coal which is washed contains 15 per cent water and fire-clay brick are more resistant to moisture than silica brick. In the U. S. coals are not washed and hence contain only 5 per cent moisture and therefore silica brick are used, being superior in heat conductivity to the fire-clay brick. The so-called "fire-clay" brick used in coke oven construction contain a higher per cent of silica than most fire clays and are made by mixing a silicious material like ganister with a high-grade fire clay. In a satisfactory brick the silica content should not be less than 80 per cent, ferric oxide should not exceed 2 per cent, the alkalies should be less than 1.3 per cent, and the lime and magnesia about 0.5 per cent. Regarding texture of brick it was found (1) fine-grained material is generally less refractory and more susceptible to chemical attack than coarser-grained material; (2) coarse-

grained material resists sudden changes of temperature better than fine-grained; (3) grain size obviously affects porosity and permeability; (4) grain size affects heat conductivity; and (5) fine-grained material appears to resist abrasion better than coarse-grained. Expansion tests under heat showed that bodies containing grog had less expansion than the neat clay while increasing grog decreased the expansion. If salt is present in the coal it would readily combine with the free quartz and fire clay. Iron oxide would become volatile from the chlorine and thus penetrate further into the brick. By washing the coal with hot water most of the soluble salts are removed. Tests were made on the fluxing effect of unwashed and washed coals by heating pieces of fire clay in a crucible with 10 grs. of the various coals. This was repeated twice and the clay was washed free from soluble salts. The fire clay contained 1.7 per cent alkali reckoned as K_2O. After the test it contained the following percentages:

	With unwashed coal, per cent K_2O.	With washed coal, per cent K_2O.
Coal No. 1	2.38	1.78
Coal A	3.09	2.46
Coal B	2.20	1.96
Coal C	2.75	2.28

Similar experiment to determine whether moisture favors the action of salts on coal showed that it does as is shown by the following results:

	Dry coal, per cent K_2O.	Moist coal, per cent K_2O.
Coal No. 1	1.77	2.43
Coal A	0.89	1.94
Coal B	0.59	0.68
Coal C	1.94	2.25

H. C. SCHUREICHT.

Refractory products with a fixed volume; zircon, refractory mineral and abrasive. M. A. BIGOT. *Céramique*, 37, 191–193 (1919). Refractories used are chiefly (1) silica products; (2) bauxite brick; (3) fire-clay brick; (4) fire clay plus graphite; and (5) magnesite. The volumes of all of the above products change with temperature. The volumes of all but the silica products decrease with increase in temperature while those of the silica products increase with an increase in temperature. A class of refractories whose volumes remain practically constant are as follows. Natural products such as natural corundum, natural zircon, natural graphite and spinels such as the iron-chrome spinel. Artificial products such as artificial corundum, bauxite fused in a cupalo, carborundum, fused quartz and artificial graphite. This investigation was limited to zircon. The fusion point of zircon is above 2000° C. When burned to 1720° C the contraction was 0.55 per cent, the apparent density 2.90, and the porosity 9.0 per cent. A mixture with 3–4 per cent lime produces a product which when burned to 1500° C has a porosity of 4–7 per cent. The fusion point of the mixture is 2000° C. The addition of oxide of

iron lowers the melting point considerably. For instance, a mixture of 83 parts zircon, 5 parts slaked lime and 12 parts iron oxide had a fusion point of 1820° C. The addition of 8 per cent kaolin produced a product having a fusion point of 2000° C. A mixture of equal parts of kaolin and zircon had a fusion point of 1460° C. In this manner it behaves very similarly to glucinium oxide, which melts at 2400° C, while an emerald, which is a mixture of glucinium and kaolin, melted at 1470° C. In slagging tests it was found that zircon was resistant to basic and acid slags, being superior to most refractories in this respect. As an abrasive it may be classed with corundum and carborundum. H. G. SCHURECHT.

Chrome brick. *Brit. Clayworker*, **28,** 178 (1919).—Chrome brick are at the present time in less demand than magnesite brick. This is due largely to the difficulty of obtaining chrome ore of good quality but this difficulty has decreased and the time is not far distant when chromite will be used extensively. Chrome ore has the advantage over silica, clay or magnesite in that it is neutral in character. Chrome ore is one of the chief sources of the metal chromium, now extensively used in alloy steels, and for this reason the ore used for refractories must be of low quality or its cost would be prohibitive. At the Chaltane brick works in Russia these low-grade ores are purified by a secret process. Brick of good quality may be bonded with fire clay or lime. The brick are burned to 1500° C and may be stacked in a kiln to the height of 10 feet. The brick have a cold crushing strength of 1800–5800 lbs. per sq. in. When lime is used as a binder the burning shrinkage is small but when clay is used it is comparatively large. Lime should not be used in quantities over 5 per cent. Lime bonded brick are more resistant to heat than clay bonded brick. The average clay bonded brick has a softening temperature of 1700° C while the lime bonded brick withstands a temperature above 1850° C. The crushing strengths of chrome bricks are higher than those of magnesite bricks. H. G. SCHURECHT.

Iron oxide and silica brick. *Brit. Clayworker*, **28,** 179–180 (1919).—Silica brick containing iron oxide but no lime were soft when burned while those containing lime were hard. A microscopic examination showed that brick free from lime contained little or no tridymite. Those in which lime and iron oxide were used showed considerable tridymite. This is to be expected as tridymite is only formed from silica which has been in solution and in brick free from lime little fusion occurs. The presence of iron oxide did not reduce the refractoriness of the brick very much under oxidizing conditions—even when 30 per cent was used. When heated under reducing conditions the refractoriness was decreased much more, *i. e.*, about four cones for 30 per cent iron oxide. The fluxing action of iron oxide is much greater for silica containing a high per cent of impurities such as potash, soda, lime and magnesia. For example, the refractoriness of a silica brick high in these impurities was decreased two cones upon the addition of one per cent of iron oxide to the

mixture. The iron oxide should also be fairly pure as any impurities present would facilitate fusion. The addition of iron oxide together with lime is recommended when pure silica is used. H. G. SCHURECHT.

Lime and Cement.

The cause of unsoundness in portland cement. Further discussion. B. F. ERDAHL. *Concrete, Cement Mill Section*, **15**, 51 (1919).—This is a further discussion of the subject of unsoundness, following those articles given in previous abstracts (THIS JOURNAL, **2**, 673 and 960). The author takes up the question of the embedding theory, *e. g.*, unsoundness is due to particles of free CaO embedded in fused particles of clinker. All cement clinkers contain free or uncombined lime in the clinker. But $3CaO.Al_2O_3$, $2CaO.SiO_2$, and compounds of Fe, Mn, MgO, and the alkalies exist enclosed in a magma of fused $3CaO.SiO_2$. These compounds tend to hydrate as well as does the free lime when gauged with water. The formation of the clinker is suggestive. The limestone is finely ground and evenly distributed throughout the raw mix prior to entering the kiln, and becomes calcined before reaching the clinkering zone. In the calcined condition the CaO exists as a fine dry powder, whose particles are extremely small, possibly of near-molecular size. In the clinkering zone the CaO particles become fused in the magma and the greater part of the CaO is used in the chemical combinations taking place. The remainder goes into solution or into a segregated viscous state rather than into the form of nuclei. When the clinker is ground some of these particles of near-molecular size will be liberated, but a great many are too minute to be reached through mechanical means and remain embedded in the clinker. This will be the case with all cements both sound and unsound. If the CaO particles hydrate on addition of water, the soft-burned clinker should prove sounder than the hard-burned. The latter, however, is known to be the sounder. If the particles do not hydrate in the "time of set" pat, the investigators who favor the embedding theory assume that hydration will occur in the boiling test. It is doubtful, however, if any more hydration of free CaO takes place at 100° than at 20° C. This can be proven by making a regulation pat of a sound cement, allowing it to set, and then passing it through the boiling test. If it is then ground to a fineness equal to that of the original cement and another pat made, it will set. If it is then boiled it will pass the test. This experiment shows that unhydrated compounds existing in the boiled pat but partly liberated through the second grinding, hydrate under the second gauging and cause a set. These unhydrated materials existing in the original pat consist of both silicate compounds and free CaO. The quickly acting $3CaO.Al_2O_3$ has probably become completely set in the first set. The second set is then likely due to setting of unhydrated silicates. In grinding, the particles of clinker will break along the lines of least resistance formed by the CaO particles, which will thus be released, and hydrated on addition of water. Unsound cement will cure in air-tight receptacles where no moisture can reach it. This fact points to another cause than embedded CaO for the

condition of unsoundness. In the cement industry the term "overburned clinker" refers to exceedingly hard-burned clinker. From the chemical point of view overburning refers, not to a physical condition but to the chemical condition existing in the clinker when volatilization of essential constituents takes place. Unsoundness in the underburned cement is not due to free CaO, but to $2CaO.SiO_2$, which is very slow setting. In the experiment mentioned, the first set was due to $3CaO.SiO_2$ and $3CaO.Al_2O_3$ which set more quickly than does $2CaO.SiO_2$, then the latter caused the second set. These processes would cause unsoundness when the cement was put to practical uses. The degree of unsoundness is then determined by the per cent of $2CaO.SiO_2$ present, which in turn depends on the temperature of burning. Hence the most effective means of preventing unsoundness is the use of a higher clinkering-tenperature. F. A. KIRKPATRICK.

The cause of unsoundness in cement. RICHARD K. MEADE. *Concrete C. M. S.*, **15**, 70 (1919).—The following are observations based on the practical experience of the writer. Excess of fluxes is of little assistance in producing sound cement. It is not easy to make sound cement from materials high in iron. Since clinker is very porous, the free lime in it should hydrate in the 24-hour storage period of the test pat. Experiment has shown that cement will cure in air-tight receptacles. Neither the free lime theory nor the "dusting clinker" theory are entirely acceptable. Chemists probably do not all mean the same thing when they speak of "the dusting of clinkers." The only "dusting clinker" ever observed by the writer has been produced by a relatively high silica mix. Judging from tests, high lime cements are most apt to be unsound, and they also have the greatest quantity of cohesive constituents. Gypsum, plaster of Paris, or calcium chloride added to cement often make it sound. Assuming that the free lime is locked up inside a minute particle of clinker, do these substances effect its hydration? Concrete may become sound with time; that is, if a number of pats of unsound cement are made at the same time and given the boiling test at intervals of a week, a time is eventually reached when they will stand the test perfectly. A great trouble with all our cement theories is that they explain some things quite well and others not at all. F. A. KIRKPATRICK.

CERAMIC PATENTS.

G. E. MIDDLETON, *Abstractor.*

General.

Kiln. J. C. SCHAFFER, U. S. 1,318,806, October 14, 1919. A series of normally operating, round, down-draft kilns are connected in series by underground and overhead ducts so that they may operate continuously. The products of combustion pass downwardly into the underground duct, thence upwardly through the next adjacent kiln containing green ware, into the overhead duct and out

Extraction and recovery of potassium or potassium salts from potassium bearing minerals. E. A. ASHCROFT. U. S. 1,320,193, October 28, 1919. Potassium or its salts are extracted from minerals such as orthoclase feldspar, micas, alunite, leucite, and from cement-kiln dust, blast-furnace dust, and so forth. The potassium-bearing material mixed with carbon or other reducing agent is treated with chlorin gas in a fused medium as, for example, potassium chloride at a temperature of 800° to 1100° C. The potassium present is thus converted into the normal chloride. A catalyzer, such as ferrous chloride, which absorbs chlorin and passes it on may be used, thus causing greater rapidity of reaction.

Process of recovering potassium salts from silicates. R. S. EDWARDS. U. S. 1,320,212, October 28, 1919. Potassium-bearing silicates are heated in a rotary kiln with sodium chloride and calcium hydroxide to the fusion point of the chloride. The hydroxide is reduced to the oxide with evolution of H_2O in the presence of which the sodium chloride breaks down and combines with the silicates, forming soluble potassium chloride and with a portion of the silicate as sodium silicate. This mass is discharged into water and the soluble potassium chloride recovered, the calcium oxide being hydrated and thus prepared for further use.

U. S. 1,320,211 discloses substantially the above without the regenerative treatment of the calcium hydroxide. Steam may be used to supply the H_2O necessary for the reaction.

Brick or Tile Press. J. T. AND S. JACKSON. U. S. 1,320,471, November 4, 1919. A toggle dry press automatically operated to feed, press and discharge. One notable feature is the separate feeding of facing and body material to the mold and the pressing of both in one operation.

Refractories.

Fire-resisting composition. R. F. BOLT. U. S. 1,318,960, October 14, 1919. This composition is designed especially for use in the lower portions of heating furnaces employed in steel mills. It consists of clay, common clay or fire clay, 25% and roll scale 75%.

Refractory material and method of making it. B. ENRIGHT. U. S. 1,319,056, October 21, 1919. The objectionable impurity of silica in dolomite used as a basic refractory is eliminated by mixing the dolomite with from 3 to 4% iron ore, pulverizing the mixture and burning it in a rotary kiln at 2700° to 3000° F. The silica is thereby caused to combine with the calcium and magnesium and so rendered innocuous.

Glass.

Means for severing and distributing molten glass. J. E. POTTER. U. S. 1,317,176, September 30, 1919. A continuously flowing stream of molten

glass is automatically severed and the successive portions distributed among a series of molds.

The molds A, B, C (see figs.) upon rotary table 3 pass in succession beneath orifice 14 from which molten glass is flowing. Guiding and distributing members 9a rotating with the molds deflect the stream of glass and coöperate

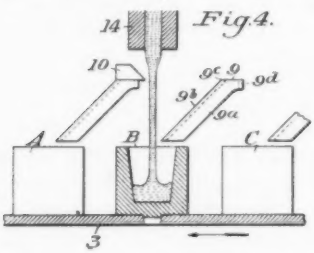

Fig. 4.

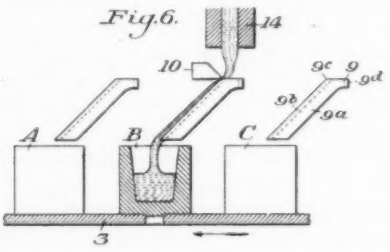

Fig. 6.

at the proper time with fixed member 10 to shear the glass, as indicated in Fig. 6. By this time the succeeding mold is in position to receive its charge and the operation is repeated.

Process of finishing the surfaces of lenses. L. W. BUGBEE. U. S. 1,317,481, September 30, 1919. A lens surface is simultaneously polished and treated chemically with the result that the nature of the lens is changed in such a way as to lower its reflection coefficient. A solution of hydrogen sulphide in ammonia mixed with iron peroxide and water is given as an example of the materials used.

High-speed glass-delivery apparatus. A. L. SCHRAM. U. S. 1,317,827, October 7, 1919. The gathering and severing tool is situated immediately below the discharge orifice and the rotary table of the forming machine immediately below this. The forming table bears a series of cups which are passed intermittently beneath the orifice and gathering and severing tool. When these cups are at rest in position to receive a charge, suction means situated beneath the table at that point coöperate with them to accelerate the flow of glass. This construction minimizes the distance of glass travel in the discharge orifice to the mold and thus results in greater speed of operation.

Apparatus and method employed in the manufacture of window-glass cylinders. J. H. CAMPBELL. U. S. 1,319,050, October 7, 1919. In the manufacture of window glass cylinders any variation in temperature of the surface glass in the pot from which the cylinder is being drawn causes the cylinder to move off the center and toward one side of the pot, resulting in an uneven thickness of the cylinder walls. Unsymmetrical heating of the pot before the glass is ladled into it, is frequently the cause of this. In order to obviate this the inventor places the pots upon a rotary table, two of the pots

being under fixed heaters while a third is being drawn from. The heaters are equipped with burners having universally swiveled joints which permit heating of the pots in any desired manner.

Process of making bottles. M. NIVEN. U. S. 1,318,170, October 7, 1919. "Sprinkler bottles," that is, those having neck passages of extremely small bore are made by this process. After the bottle is blown the neck portion is clamped between two jaws and the bottle spun or rotated. The capillary passage is formed by a needle held between the jaws. Lime glass may be used.

Apparatus for manufacturing window-glass cylinders. H. J. WALTER. U. S. 1,318,190, October 7, 1919. A hoisting cage carries a blower having a downwardly projecting air outlet constructed to make an air-tight but yielding and flexible connection with the upper end of the blow pipe carrying the bait. The air pressure required to prevent the collapse of the cylinder is very small, and if during the draw the motor stops the air within the cylinder would be free to escape were it not prevented. By means of this invention the back leaks through the blower and the consequent collapse of the cylinder is prevented.

Glass-forming machine. R. LAFRANCE. U. S. 1,319,098, October 21, 1919. In bottle-blowing machines a head is provided to engage the neck of the bottle and hold it in place during the opening movement of the blow-mold. The head is then withdrawn and the bottle falls without rubbing against and wearing the edge of the mold. Sticking to the mold is also prevented. The head carries a removable disk made of wood which is readily replaceable. As the surface of the wood becomes slightly charred by the hot glass it provides a heat-insulating surface which does not crack the bottle necks.

Apparatus for making sheet-glass. M. J. OWENS. U. S. 1,319,175, October 21, 1919. Molten glass is drawn upwardly in a continuous sheet from the tank and over a bending device to a horizontal position and thence through a lehr. The bending device comprises an endless chain of blocks over which the sheet of glass is drawn. This chain runs continuously in one direction, the blocks being kept moist to prevent overheating by passing through a trough of water on the lower run. This moisture also provides a surface which does not mar the glaze. The edges of the sheets pass over rotary hollow conical drums which prevent catching on the edges of the bending blocks and also prevent sidewise motion of the sheet due to the lateral pull of the moving chain.

Manufacture of sheet glass. J. PROEGER. U. S. 1,320,091, October 28, 1919. In the ordinary processes of drawing sheet glass the outer edges cool more rapidly than the center with resultant irregular shrinkage and warpage. To obviate this the glass is drawn through a heat-distributing casing which utilizes the heat from the furnace in such a way as to insure uniform heat conditions about the sheet and a gradual cooling.

Cylinder-splitting apparatus. C. F. WARRICK. U. S. 1,320,947, November 4, 1919. A burner is reciprocated longitudinally of and beneath the glass cylinder until a cracking tension is created whereupon an abrasive-pointed tool scratches the inside of the cylinder above the heated section and effects the splitting.

Apparatus for transferring glass articles to annealing-furnaces. J. P. MINGLE AND A. G. WILSON. U. S. 1,321,072, November 4, 1919. An apparatus for transferring glass articles such as jars or bottles from an endless conveyor into an annealing lehr. The transferring mechanism comprises a rotary table provided with peripheral semi-cylindrical pockets which receive the jars from the conveyor and deposits them upon the lehr pans.

Glass-mold composition and method of making it. B. C. GILLIGAN. U. S. 1,319,151, October 21, 1919. Molds, plungers, etc., used in molding glassware, are made of a mixture of powdered graphite and retort carbon, bonded with a water solution of caramelized sugar. Molds of this composition are said to produce ware of undimmed luster comparable to that of ware blown without molds.

Faucet for delivering molten glass. C. H. HUBBARD AND G. R. RUPERT. Reissue 14,745, October 28, 1919. Original patent 1,200,195, October 3, 1916.

Lime and Cement.

Gas-fired shaft-kiln. A. AND W. STEIGER. U. S. 1,317,603, September 30, 1919. Lime, magnesite or ores may be calcined in this kiln. The novelty resides primarily in that the cross-section of the shaft is suddenly increased in the cooling zone a considerable amount, preferably immediately below the combustion zone. The air for combustion is introduced near the bottom of the cooling zone and the loosening of the material in this zone due to the larger cross-section facilitates the passage of this air and the cooling of the material.

Rotary kiln for calcining alunite. H. F. CHAPPELL. U. S. 1,317,686, October 7, 1919. This kiln is designed so that the products of combustion of the fuel are completely oxidized before mingling with the oxide of sulphur fumes evolved from the alunite.

Rotary furnace. J. B. GAFFNEY. U. S. 1,318,141, October 7, 1919. Means are provided for removing the material without causing the stopping of the apparatus or the introduction of outside air. That portion of the chamber situated within the furnace is protected from the deterioration caused by combustion gases by a sleeve of refractory material. Means are provided to prevent caking of the material being treated.

Composition matter for building. BRICKS L. HALFER. U. S. 1,317,288, September 30, 1919. This composition comprises sand, crushed stone, screened cinders, granular iron and cement.

Composition for floors. F. ROMANO. U. S. 1,317,525, September 30, 1919. A building material which consists of Portland cement mixed with granite dust or flour.

Plastic composition. B. F. BICKEL. U. S. 1,317,680, October 7, 1919. A composition comprising lime, 9 parts; aluminum sulphate 1 part; a filler; and sufficient liquid to form a plastic mass.

Asbestos cement. H. S. ASHENHURST. U. S. 1,317,853, October 7, 1919. An asbestos cement composed of finely divided particles of the double silicate of magnesium and calcium, having a weight of approximately 25 pounds per cubic foot.

Material for making monolithic structures. B. B. GRUNWALD. U. S. 1,318,075, October 7, 1919. A material consisting of a wet mixture of magnesium oxide, magnesium chloride and a mixture of dead burned and crude, finely-divided magnesite.

Material for closing off water in oil-wells. B. B. GRUNWALD. A material suitable for this purpose consisting of a mixture of a magnesium cement, dead burned and crude finely divided magnesite and a calcium salt.

Method of hydration. W. W. RHODES. U. S. 1,318,021, October 14, 1919. The akaline earth substances to be hydrated are maintained in a moistened condition at a temperature below 100° C. but under pressure such that steam is generated within the mass.

Method of promoting plasticity of mortar materials. W. W. RHODES. U. S. 1,318,022, October 14, 1919. Alkaline hydrates, notably those of calcium and magnesium in pulverulent condition, are subjected to a pressure of only one-half atmosphere for a period of one hour. A denser material is said to result which requires less water to work up into a plaster, and the plaster is said to have greater smoothness and strength and less porosity than one employing untreated hydrates.

Manufacture of portland cement. C. PONTOPPIDAN. U. S. 1,320,172, October 28, 1919. The wet process of manufacturing Portland cement is objectionable in that the slurry often sets to such an extent as to prevent its being handled properly in the apparatus employed. The object of this invention is to make possible the use of the wet process by incorporating a setting preventive with the slurry and subsequently destroying it during calcination. The raw materials such as blast furnace slag and limestone are ground together in water and about a quarter of 1% of sugar added. The sugar acts as a setting preventive but is subsequently eliminated during the clinkering. Molasses and other substances such, for example, as oxy-acids, oxy-aldehydes and oxy-ketones may be used.

NOTE.—Copies of these patents may be obtained for ten cents each by addressing the Commissioner of Patents, Washington, D. C.

AMERICAN CERAMIC SOCIETY.

Acquisition of New Members during November, 1919.

Associate.

Boyden, Mrs. E. S., Librarian, American Optical Co., Southbridge, Mass.
Christopher, Arthur B., Evens & Howard Fire Brick Co., St. Louis, Mo.
Coulston, E. V., Secretary, Rock Island Stove Co., Rock Island, Ill.
Harris, Marshall W., 227 East Park Place, Oklahoma City, Okla.
Hasslacher, George F., Salesman, Roessler & Hasslacher Chem. Co., 400 W. 147th St., New York City.
Heath, Fred T., 4505 Eighteenth Ave., N. E., Seattle, Wash.
Landsheft, C. F., Supt., Vitrolite Co., 939½ Market St., Parkersburg, W. Va.
Sladek, George E., 211 E. Daniels St., Champaign, Ill.
Wey, Harold B., Vice-Pres. and Gen. Mgr., Atlantic Terra Cotta Co., 1302 Third National Bank Bldg., Atlanta, Ga.

Foreign.

Travers, Morris W., D.Sc., F.R.S., Beacon Hall, Priory Garden, Highgate, London, England.

Corporation.

Los Angeles Pressed Brick Co., Frost Bldg., Los Angeles, Cal.

Acquisition of New Members during December, 1919.

Associate.

Beasley, H. C., Gen. Supt., Coonley Mfg. Co., Cicero, Illinois.
Blodgett, Malcolm, Supt., R. Gustavino Co., Woburn, Mass.
Goheen, John P., Sec'y., The Brown Instrument Co., Philadelphia, Pa.
Grace, Richard P., Supt., Mutton Hollow Fire Brick Co., Woodbridge, N. J.
McClafferty, Harry J., 1447 Peach St., Rockford, Ill.
Peck, Albert B., Associate Physicist, Bureau of Standards, Washington, D. C.
Ryan, John F., Sec. and Mgr., Mutton Hollow Fire Brick Co., Woodbridge, N. J.
Ryan, Lawrence C., Asst. Mgr., Mutton Hollow Fire Brick Co., Woodbridge, N. J.
Ryan, Joseph P., Pres., Mutton Hollow Fire Brick Co., Woodbridge, N. J.
Watson, Harold L., Thomas Laboratory, General Electric Co., West Lynn, Mass.

Foreign.

Gentil, E., Engineer, Glaeerie St. Gobain, 1 Bis Place des Saussaics, Paris, France.
Niemura, Nobutaro, Nishimura Chemical Ceramic Laboratory, 1197 Nanba Ashiwarachs, Minamiku, Osaka, Japan.

Corporation.

A. J. Lindemann-Hoverson Co., Milwaukee, Wisconsin.

LOCAL SECTIONS.

Pittsburgh District Section.

The Pittsburgh District Section held its last meeting of the year at the Mellon Institute in Pittsburgh on December 30, 1919. The meeting was called to order at 9.30 A.M. and Mr. Hice presided. Mr. F. H. Riddle had resigned as secretary some time previous to this meeting and Mr. L. R. Office was appointed secretary *pro tem.* Over 35 attended the meeting.

Mr. Bleininger told about the intended visit of members of the English Ceramic Society to the United States next summer and made a motion that the chairman be empowered to appoint a committee, which is to lay out a program for entertaining the English visitors in this district. Motion seconded and passed.

The committee on nominations proposed a list of officers and Mr. J. W. Wright moved to elect the officers as selected by the committee. Motion was seconded and passed unanimously.

Officers for the coming year were elected as follows: Mr. C. R. Peregrine, *Chairman;* Mr. J. Spotts McDowell, *Vice-Chairman;* Mr. Leon R. Office, *Secretary;* Mr. Thos. H. Sant, *Treasurer;* Mr. Francis W. Walker, *Councilor.*

Following the business meeting several very interesting papers were read as follows:

"Note on Glass Refractories," A. V. Bleininger, Bureau of Standards, Pittsburgh, Pa.

"Notes on Clay Pits of England," Thos. H. Sant, John Sant & Sons Co., East Liverpool, Ohio.

"Refractory Cements," Raymond M. Howe, Mellon Institute, Pittsburgh, Pa.

"A Lining for Glass Pots," Dr. S. R. Scholes, H. C. Fry Glass Co., Rochester, Pa.

"Refractories for the By-Product Coke Plant," Leon R. Office Mellon Institute, Pittsburgh, Pa.

The papers by Messrs. Howe and Office were illustrated by lantern slides

Meeting adjourned.

L. R. OFFICE, *Secretary.*

Chicago Section

At a meeting held in Chicago, on Saturday, November 29th, the Chicago Section of the American Ceramic Society elected the following officers for the ensuing year:

Chairman—Mr. H. T. Bellamy, Western Electric Co., Hawthorne Wks., Chicago, Ill.

Vice-Chairman—Mr. B. S. Radcliffe, Midland Terra Cotta Co., Chicago, Ill.

Chairman Program Committee—Mr. B. T. Sweeley, Western Electric Co., Chicago, Ill.

Chairman Membership Committee—Mr. E. A. Brockman, Roessler and Hasslacher Chem. Co., Chicago, Ill.

Two very interesting papers were given at this meeting, one on "Phosphate Cement," by Prof. R. K. Hursh, of the University of Illinois, and the other on "Notes on Silica Brick," by Mr. Geo. E. Sladek, graduate student of the University of Illinois.

F. L. STEINHOFF, *Secretary-Treasurer.*

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COMPILED BY HOMER F. STALEY, C. C. ANDREW AND A. J. LAMBERT.

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(A) Abstract
(D) Discussion
(E) Editorial
(O) Original paper
(P) Patent

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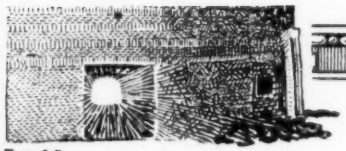

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The optical pyrometer can be carried from place to place and successive calibrations made much more quickly than by means of a standard thermocouple inserted near the working couple.

The optical pyrometer is also used to explore furnace interiors, thus ascertaining whether or not the temperatures by the thermocouples are representative.

Nearness to the hot object or large areas to sight at are not required. Color-blindness and similar defects of vision do not vitiate results, as different observers agree within 10° F.

The Leeds & Northrup Optical Pyrometer, complete with battery, rheostat and milliammeter in a case to be slung from the shoulder, is sent, subject to return in ten days or payment in 20 days, to anyone supplying good references.

No. 8600 Optical Pyrometer, range 1100 to 2500° F $105.25

No. 8610 Optical Pyrometer, range 1100 to 3200° F 184.25

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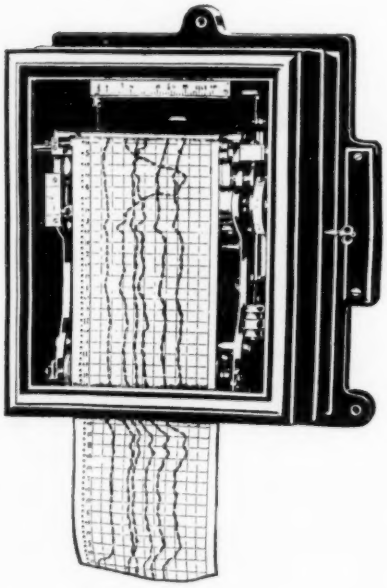

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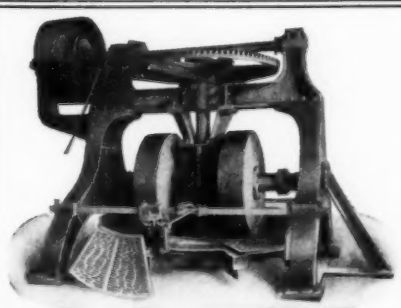

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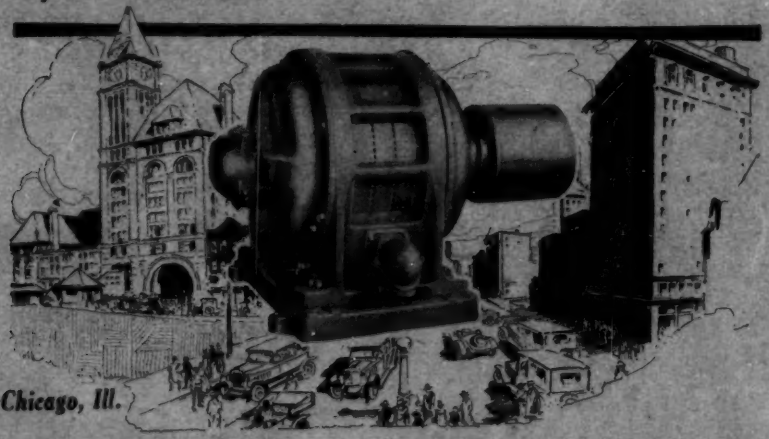

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